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Analyzing Health Innovations in a School Lunch Program

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Abstract

Hopkins School District in Minnesota implemented an innovative school feeding program, which provides nutritionally sound foods that appeal to students. With access to a unique data set containing students' food service purchases and demographic data from Hopkins High School, we use logit models to analyze the impact of different phases of the program on participation rates, as well as the effect of demographic factors. A relative healthfulness index for the foods purchased is calculated based on information provided by the school dietitian. This index is used to analyze the impact of demographic variables, student lunch expenditures, and program changes on students' lunch consumption. The results of the econometric models indicate that the program innovations have caused positive behavioral changes in most students and that students are choosing healthier foods than under the old program. Moreover, we find that ethnicity and gender play major roles in determining how students react to the new program in Hopkins.

Analyzing Health Innovations in a School Lunch Program

Ninety-nine percent of public schools and 83 percent of public and private schools combined participate in the federal lunch and breakfast programs. In the course of a K-12 education, the average student will eat 3,120 lunches at school. Some will eat an equal number of breakfasts. In 2004, U.S. schools served 4.8 billion lunch meals and 1.5 billion breakfasts, according to the U.S. Department of Agriculture (2005c). For many, especially those enrolled in federally subsidized free and reduced-price meal programs, these were the main meals of the day.

Meanwhile, the American Obesity Association (2005) reported that 30.3 percent of children aged 6 to 19 were overweight or obese. The proportion who are obese tripled between the early 1970's and 2000, with serious consequences for their long-term health. Many factors are behind this trend. Some are in the home, or are the result of marketing decisions by large food companies, both of which can be influenced only indirectly by public policy. However, a major intersection between food consumption and young people's lives occurs in the school lunchroom. What is served and eaten there can, in principle, be changed.

Unfortunately, the lunches provided in most schools across America contribute to adolescent obesity rather than ameliorating it. In a nationwide assessment, the U.S. Department of Agriculture (USDA) found the average lunch served in 1998-1999 met the dietary guidelines of fewer than 30 percent of total calories from fat and less than 10 percent from saturated fat in only one out of seven secondary schools (USDA, FNS, 2001, p. 2). Many secondary students eat high fat cheeseburgers, French fries and pizzas on a daily basis. In many 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 being offered with the full meal (Becker and Burros, 2003).

School food service directors often must focus on ease of preparation instead of creating 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. Moreover, 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. In short, most schools have rejected any responsibility for promoting the good health of their students and the development of healthy life-long dietary habits in the lunchroom (USDA, FNS, 2001).

Recently, some school districts have taken steps to change their feeding 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 feeding 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, a suburb of Minneapolis, Minnesota, has been one of the innovators. Royal Cuisine, its new food service program, has improved the quality of food served, the variety of healthful choices available, and the school feeding environment. Because of these changes, Hopkins High School provided a

real-time experiment to study the lunch consumption patterns of adolescents and how they might be changed.

With access to a unique dataset, we examined consumption patterns over the past three years (2002-2005) in Hopkins High School and the impact of the food service changes on a measure of nutritional health. First, we estimated the role demographic variables played in choosing to participate regularly in the school lunch program, as well as to purchase à la carte items. Second, a dietician-developed index of healthfulness was applied to the specific food items offered. This measured healthiness of foods purchased by a student over a ten-day period. Econometric methods then examined the factors affecting how a student's choices changed after the program innovations. This real-time experiment provides one of the first in-depth economic examinations of the impact of comprehensive reforms to promote healthier eating in a school lunch program.[1]

Background

The National School Lunch Program (NSLP) is a federally funded meal program that provides assistance to public and private nonprofit schools. Participating schools receive cash subsidies and free commodities from the USDA for every meal served. In return, these schools must satisfy USDA's nutritional requirements for full meals served and provide free or reduced-price lunches to eligible children. During 2004-2005 the reimbursement rates for free, reduced-price and paid lunches were $2.24, $1.84, and $.21, respectively. While schools are required to comply with the dietary guidelines for full (reimbursable) meals, the nutritional content of à la carte items, which are referred to as "competitive foods" by USDA, are not regulated, as long as

the food item in question is not one of minimal nutritional value, as defined by the USDA (Guthrie, 2003 and USDA, FNS, 2005b).

Previous Research

Given the variety of alternatives to participating in the NSLP that children face (such as bringing a lunch, eating lunch away from school, etc.), it is important to understand what factors drive participation. Akin, et al. (1983) estimated demand for the NSLP using an ordered probit analysis, finding that white students and students with higher incomes were less likely to participate. The nutritional impacts of the program were analyzed by Akin, Guilkey and Popkin (1983), who found that students who participated in the NSLP improved their intakes of vitamins and minerals over a 24-hour period 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. Using a fixed effects model, NSLP participation led to an improvement in the 24-hour intake of six vitamins and minerals. Participants were also found to consume higher levels of fat, but less added sugars than non-participants.

A clear 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 and adolescent obesity. In addition, they found that the probability of a school resorting to vending machine contracts increased students' Body Mass Index (BMI) levels. Even so, the nutrition literature suggests that interventions to promote healthy eating can work. Studies typically focus on evaluating the impact of controlled interventions, frequently designed by the researchers, which are implemented on a trial or temporary basis. French et al (1997) found that when salad prices were lowered in a cafeteria setting (in combination with advertising schemes), the quantity sold increased, suggesting that changes can be induced by

price manipulations and promotions. Perry et al (2004) assigned schools randomly to a control or an intervention group, in which interventions were successfully initiated to encourage fruit and vegetable consumption.

Beyond simply offering nutritious foods, it is widely recognized that the school lunch environment can be important in increasing health consciousness affecting students' consumption patterns. Simply offering nutritious foods does not necessarily increase participation if foods are not appealing, resulting in major increases in plate waste. 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.

A Healthy Eating Index (HEI) was designed by USDA to measure eating patterns on a scale of 0-100, based on 10 components capturing whether dietary guidelines were being met through indicators such as percent of energy from fat, saturated fat consumption, cholesterol and sodium intake and variety of foods consumed (Bowman, et al, 1998). Variyam, et al (1998) used the 1989-90 Continuing Survey of Food Intake by Individuals (CSFII) and the Diet and Health Knowledge Survey (DHKS) to estimate the impact of demographic and nutritional knowledge variables on HEI. They found that nutritional knowledge was a factor in healthy eating, even after controlling for socioeconomic characteristics. For other studies employing HEI, see Basiotis, Hirschman and Kennedy (1996), and Bowman, et al (1999).

The Hopkins Food Program: Royal Cuisine

Over the past few years, the food service program in the Hopkins School District underwent dramatic changes. Until 2003, school food in Hopkins was much like most districts across America. Foods in the main cafeteria line were easy-to-prepare and the à la carte items available 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 9,000 students. To implement a new program, in July 2003, the Superintendent hired a Food Service Director who was a professional chef with a restaurant and hotel career.

The innovations began at the high school, opening an optional window called the Health Nut Café, which served only foods free of transfats, with low levels of sugars, including high fructose corn syrup (HFCS), and high in fiber. The offerings included organic whole grain cookies, 100% juice drinks, and freshly made salads and sandwiches. At first only athletes and young women were drawn to it, but by year's end its sales had risen steadily, due both to increased student and teacher demand. Later that year, the vending contract with Pepsi was cancelled, 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, adding a stir-fry station, ethnic food choices and homemade pizzas with whole wheat crusts and scratch ingredients. The new program was named Royal Cuisine and has changed food service operation in all schools within the district, although the most profound changes are visible in

Hopkins High School, the focus of this study. The new Food Service Director also revamped the catering arm of the school, and revenues climb from $40,000 to $400,000 a year.

By shifting the focus to more nutritious foods prepared on site, the new program began to teach life-long eating habits to the students enrolled in Hopkins. No longer were meals simply warmed prior to service; cooking from scratch became the norm and students ate from plates with silverware. 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 reimbursable meal options, were introduced in the high school cafeteria. The Tuscan Oven offered made-from-scratch Italian entrees and side dishes. Ethnic Adventures offered a variety of foods to which students might not otherwise be exposed, such as spätzle, pot stickers, and Szechwan stir fry.

Because preparing foods from scratch and providing more fresh fruits and vegetables is more expensive, prices increased.[2] 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 have not increased substantially due to efficiency gains. It should be noted that Hopkins High School is a closed campus, so students do not have the option of going off campus to get lunch.

Data

In order to understand the data used in the following analysis, it is useful first to describe the real-time setting from which the data were generated. Each student in the Hopkins School District has a personal spending account with an associated Personal Identification Number

(PIN) that is used for purchasing food. Students and their families deposit money into their accounts on a rolling basis. On any given day, a student purchasing food items in the school enters his or her PIN at the point of purchase and a cashier enters the item number of the foods chosen by the student. Sales data are then kept electronically by Royal Cuisine. The data used in the analysis can be grouped into four main categories: sales, nutritional ratings for foods, prices, and student demographic data.

Sales Data

Sales data comes from the Royal Cuisine food service program. Point of Sale's (POS) reports were run for a random sample of students for November 2002, 2003, and 2004 as well as April 2003, 2004, and 2005. The students in each random sample were sophomores in 2002-2003, juniors in 2003-2004, and seniors in 2004-2005. Because the major changes implemented in Hopkins came after the new Food Service Director started in July, 2003, school year 2002-2003 will be treated as a baseline.

Daily data on the item number and the quantity purchased by each student are provided in the POS report. The item number corresponds to the food purchased for some items, and represents a food category in some cases. For example, item number 647 corresponds to a hot dog, but item number 643 corresponds to "$2.00 Miscellaneous", a category designed to capture all items costing $2.00 that do not have a separate key on the cash register. For this reason it is impossible to determine which item was purchased if 643 appears in the POS report for a student.[3] However, most item numbers correspond to a unique food product, providing a rich dataset of historical à la carte purchases.

Reimbursable meals also appear in the POS reports. For the academic year 2004-2005, it is possible to distinguish which entrée the student purchased. The side items that supplement the

entrée in order to create a reimbursable meal are not keyed in by the cashier, so they do not appear in the data. In the first two years of data (i.e. '02-'03 and '03-04) the data indicate whether the student purchased a reimbursable lunch, but not which one.

Nutritional Ratings and Relative Healthfulness Index

The second type of data employed in this analysis were nutritional ratings. For this measure, we utilized the expertise of the dietitian/nutritionist at Royal Cuisine who was trained at the University of Minnesota School of Public Health. Her approach might be viewed as a simple form of the USDA Healthy Eating Index. Each item or entree was rated as either more healthy, given a rating of (+1), less healthy (-1), or not clearly either (0), based on the nutritional content of the foods. The dietician has worked in Hopkins over the entire time period and is familiar with the food offerings at every point. The fact that she provided ratings for all years ensured consistency in this measure. As discussed in the sales section, because each entree could be paired with multiple side items, we considered the entree's rating only in the case of reimbursable meals.

Both negative and positive criteria were used for the ratings including whether the food item contains trans-fatty acids and high levels of other fats or sugars and whether it contained whole grains and fiber-rich fruits and vegetables and is minimally processed. In general, foods considered healthier are lower in fat and have more nutrients per calorie, whereas less healthful foods are higher in fat, more energy dense, and are relatively low in nutrient value. This approach is consistent with USDA's Healthy Eating Index construct (Bowman, et al., 1998). These ratings were then tied to the item numbers from the sales data. For item numbers corresponding to multiple food items, a rating of 0 was assigned unless all foods under that category had an identical rating.[4]

Using the nutrition rating data, we developed a relative healthfulness index (*RHI*). This index is the sum of the daily average ratings for a student over the first ten days in which that student made food purchases during the month. Formally, define A_{ij}^{t} as the rating assigned to student *i*'s choice of à la carte item *j* (*j = 1,…,n*) at time *t*. Define M_{ik}^{t} as the rating assigned to student *i*'s choice of meal *k* (*k = 1,…,m*) at time *t*. $A_{ij}^{t}, M_{ik}^{t} \in \{-1, 0, 1\}$. Now define the ***Daily Average Rating*** as follows: $R_i^t = \dfrac{\sum_j A_{ij}^t + \sum_k M_{ik}^t}{N_i^t}$, where N_i^t is the number of items purchased on day t by student i. Clearly, $-1 \le R_i^t \le 1$ for all *i*, and all *t*. To reflect the overall healthiness of a student's purchases, we sum over ten days. Thus we define the relative healthfulness index (*RHI*) for student *i* as $R_i = \sum_{t=1}^{10} R_i^t$. Clearly, $-10 \le R_i \le 10$ for all *i*.[5]

The first ten days in a month in which student *i* had an observed value of R_i^t were used in the analysis.[6] It is important to note that the actual observed days for each student may vary.[7] The choice set available on any given day varied only in the entrée selection in the Diner, Ethnic Adventures, and the Tuscan Grill. All à la carte items as well as Grill, Deli, and Salad options were consistently offered over each time period considered, although over time the selection varied due to Royal Cuisine's efforts to improve the quality of foods offered.[8]

Prices

Meal and à la carte item prices, the third data category, were obtained from Royal Cuisine 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 timeframe.[9]

Demographic Data

Finally, demographic data for each student were used in the analysis.[10] With the cooperation of the Superintendent and others in the District Office, access to student

demographic data held by Hopkins School District was granted. Using only the student's ID Number to preserve privacy, we linked the student's purchases to his or her demographic characteristics. Table 1 contains a summary of the demographic variables by month and year, giving the number of observations in each category.

Female and male dummy variables (with the latter omitted) were used in the regressions and statistical analysis. Data on age was also available, but because every student in our sample was in the same grade, it was not considered explicitly.[11] For each student, Hopkins School District also holds data regarding that student's ethnicity. Ethnicity was divided into five groups in the data: White (omitted), Black, Hispanic, American Indian/Alaskan/Pacific Islander, and Asian. These variables were used as indicator variables, receiving a value of 1 if the student is of that ethnicity, 0 otherwise. Because very few students in Hopkins are of American Indian/Alaskan/Pacific Islander or Hispanic ethnicity, we utilized an "Other" category, which combines these groups.

Finally, Hopkins School District has data on the federal assistance each student receives for school lunch through the National School Lunch Program (NSLP), i.e. if the student receives free or reduced-price lunch. These are the Free and Reduced variables in the following analysis with the variable for full-priced meal purchases being omitted. In some cases we chose to use the variable Assisted, which is simply students receiving free or reduced-price lunch, while Unassisted is a student receiving neither.[12] These variables served not only as an indication of the subsidy received by the student, but also as a proxy for that family's household income, which is the basis of eligibility for free or reduced-price meals.

An Analysis of Program Participation Rates

Given the major changes implemented in the Hopkins' cafeterias, it is important to examine trends in participation rates and how the choice to purchase lunch at school was affected. We estimated two logit models that used demographic variables to predict which students purchase school lunch and à la carte items regularly during each month/year combination. Statistical inference was then used to test whether participation increased over time and whether there was a significant change in student lunch expenditure under the new program. This analysis will allow us to understand how students in other districts may react to similar changes in their school feeding programs.

The first logit model estimated which factors influenced the decision to regularly eat a full school lunch meal. The dependent variable equaled one (1) if the student ate a reimbursable meal on at least fifty percent of the school days during that month, and zero (0) otherwise. The results are presented in Table 2.

Examining Table 2, it is clear that the probability of a student consuming school lunch is lower for females than males. This coefficient was significant at the 1 percent level for every month specified. The coefficient for Black was significant in two equations. A Black student was less likely to participate in November 2003, but more likely to eat a reimbursable meal by April 2005, after the program changes. The coefficient for Other was only significant in one regression (April 2004), when it was negative. The changes in the Hopkins' cafeteria made in 2003-2004 seemed to have an initial negative effect on participation by Other minorities, which was quickly overcome. The coefficient on Asian was positive and significant in November 2002, signaling that Asian students were more likely to participate in school lunch than other students prior to the program changes.

Students that received either free or reduced-price lunches (Assisted) had a greater incentive to purchase a meal rather than buying separate à la carte items or bringing a lunch from home. As expected, Assisted is significant at the 1 percent level in every equation but April 2005, when it was significant at the 10 percent level. This finding supported the evidence provided by Akin et al. (1983).

A second logit model was estimated to predict which characteristics affected the probability of purchasing à la carte items regularly (i.e., on at least half of the school days in the month). The explanatory variables chosen differed slightly from those in the previous logit model; rather than Assisted, Unassisted was chosen as the income proxy in this estimation.[13] A student with more disposable income is, other things equal, more likely to purchase à la carte items. Results are shown in Table 3.

In Table 3 the coefficient on Female was positive and significant for November 2003 and April 2004 (the first year of the major changes in Hopkins), which implied that females were especially attracted to the new, healthier à la carte choices at the Health Nut Café that opened that year. Minority students were no more or less likely to purchase à la carte items after the food service changes were introduced in 2003-04. The variable Unassisted had a positive and highly significant coefficient in every month. We believe this was due to two main causes. First, students not receiving assistance were from households with higher incomes than students receiving assistance. Second, there was no subsidized incentive for students paying the full price to purchase a reimbursable meal rather than a combination of à la carte items, which the student might prefer to the meal options.

Changes in Participation Rates and Expenditure

The impact of the new program on participation rates was of particular interest. We tested whether there has been a statistically significant change in the full meal participation rate in Hopkins. A simple procedure to test this hypothesis is McNemar's Test (McNemar, 1947); in addition, paired t-tests were conducted. McNemar's Test looks for an imbalance in the direction of change when comparing behavior in two time periods, with only the assumption that the students in each time period are the same. We picked April 2003 and April 2004 (all students appearing in both samples) as two months for comparison. These months were chosen because the new program changes began in fall 2003 and choosing the same months for each year removes the impact of seasonality. Therefore, testing April of each year will show if students changed their behavior significantly after the implementation of the new program (choosing November results in similar findings). If we assume that preferences were relatively constant over time, we infer that the change is due to the new Royal Cuisine program.

To conduct McNemar's Test, Table 4 was completed as follows. We first looked to see whether students were purchasing food often (at least 50 percent of the time) or not often (less than 50 percent) during each time period and fill in each cell accordingly. For example, the cell corresponding to the ordered pair (Eat Often '03, Not Often '04) shows that 53 individuals purchased a reimbursable lunch more than half of the time in April 2003 and changed to less than 50 percent the following year.

Under the null hypothesis, the test statistic follows an asymptotic Chi-Square distribution with one degree of freedom. Because we were interested in a behavior change, we used cells from the off-diagonal in the statistic. The test statistic, Q, was calculated as $\frac{(53-116)^2}{(53+116)} \approx 23.49$ and has a p-value of 0.0000. This is very strong evidence against the null hypothesis, so we

reject the claim that there has been no significant change in participation over this time period in favor of the alternative that students were more regularly eating school meals under the new program. The paired t-tests comparing November 2002 to November 2003 or November 2004 also rejected the null hypothesis with p-values near zero. Similarly, testing April 2003 versus April 2004 was significant at the 5 percent level. Thus there is strong evidence that meal participation increased with implementation of the Royal Cuisine program.

Not only did participation increase, but the average expenditure (the total value of all foods purchased) decreased over the time period, according to two different measures. Although the price of reimbursable meals increased during the period, average expenditure would decrease if more students bought meals and fewer students purchased multiple and/or expensive à la carte items, thus spending less money. We calculated the mean daily expenditure of all students making at least one purchase during the month. 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 vs. April 2005. The test statistics (which follow a t-distribution approximately with 792 and 851 degrees of freedom) are 152.52 and 130.95, respectively. Both tests have p-values of 0.0000. With this evidence we rejected the null hypothesis, which was especially noteworthy since meal prices actually increased over the time period. Whether expenditures changed on á la carte items is addressed in the next section.

An Analysis of the Relative Healthfulness of Consumption

The impact of the school lunch changes on what students consumed was examined next. We first discuss the theoretical foundation for this analysis and then provide an explanation of the econometric techniques used. Using ***RHI*** (described in the ***Data*** section) as the dependent

variable, we used demographic variables and expenditures to explain the relative healthfulness of consumption choices.

Theoretical Foundations and Econometric Issues

Conventionally in the literature on household behavior, we assumed that the reduced-form equations for food consumption can be derived from a household model that incorporates health production and consumption decisions (Behrman and Delalokor, 1988). Each student *i*, given his or her demographic traits and the prices of possible school lunch choices, chooses food and non-food consumption bundles to maximize his or her utility subject to his/her budget constraints.

Recall from the data section that random samples were drawn for each month/year combination. Therefore, the number of observations for each student varies by individual. This is often referred to as an unbalanced panel.[14] Simply pooling the data and estimating a regression model using OLS would be inappropriate because it would overstate the number of independent observations. Furthermore, many econometric techniques applied to cross-sectional data are not well suited to deal with unbalanced panels.

Two common approaches dealing with unbalanced panel data are random- and fixed-effects models. These models are attractive because they can both be adjusted for unbalanced panels. However, because the fixed-effects model uses differencing in the estimation, demographic variables that are unchanged over time are dropped from the estimation, which would be an inappropriate use of the data. The random-effects approach allowed us to retain the time-invariant variables in the estimation.[15]

The Two Estimation Specifications

Two specifications to estimate relative healthiness (***RHI)*** were used. For each student, both specifications used data on the first ten days in that month in which the student bought food in the school cafeteria to estimate a relative healthfulness index as described in the ***Data*** section. The first specification, which employed all six months of data, considered only à la carte purchases. This is due to ambiguity over which entrée was purchased with a reimbursable lunch during the first two years of data. The second specification considered only the 2004-2005 data, where the meal purchase data had been disaggregated. A discussion of the calculation of each follows. Following the discussion of each ***RHI*** specification, we provide empirical results using the random-effects estimation.

The first specification for ***RHI*** considered only students purchasing one or more à la carte items on at least ten days during a given month. Again, the first ten days for each student were used in the calculation. The data contained entries for each of the six months under consideration. There were 527 individuals who appeared at least once in these data; 96 students appeared exactly once, 97 twice, 74 three times, 91 four times, 77 five times, and 92 students purchased an à la carte item ten times in each of the six months. Tables 5 and 6 contain descriptive statistics for this specification by month as well as for the overall dataset.

In Table 5, we see that the minimum and maximum ***RHI*** values observed were relatively constant across months while the ***RHI*** mean showed a rather steady increase, indicating an improvement in the average healthiness of the foods purchased. At the same time, the mean expenditure, which in this case is the total only for á la carte purchases, decreased substantially from November 2002 to April 2005, so that on average students were spending less, but eating healthier food. Recall that expensive á la carte items supplied by vendors, such as Pizza Hut,

were replaced by healthier, less expensive items, such as whole-grain pizza prepared on site. This finding is particularly relevant since many school districts argue that although they would like to provide higher quality, healthier school lunch choices, they cannot because it would be unaffordable for many students.

Table 6 provides a summary of the explanatory variables, giving the number of students in each category for every month/year sample. There were few minority students and even fewer students receiving reduced-price or free meals since they were more likely to get a reimbursable meal and not purchase à la carte items.

Relative Healthiness Estimation for Á la Carte Choices

For the first estimation of RHI, three random-effects models were specified shown in Table 7. The first equation includes dummy variables for five of the month/year combinations, as well as all of the demographic variables discussed previously. The second model includes a variable designated "Improved." This variable assigns a value of 1 to the first month in the analysis (November 2002), 2 to the second, 3 to the third, and so forth. This tests the hypothesis that there has been constant (linear) improvement over the time in RHI. The third model assumed the same independent variables as the second, but added the multiplicative interaction terms Improved*Asian, Improved*Black, Improved*Other, and Improved*Male. These variables were included to test for trends for each of the respective demographic groups in terms of eating healthier lunches.

Expenditure, the amount spent by a student over the ten-day period, was positively correlated with RHI in all three regressions. This was expected, as more healthful foods are generally more expensive. The coefficient for Female was positive and significant in every equation; females were more likely to make healthy school choices than males. This finding is

consistent with previous studies tying gender to healthy eating (Variyam, et al., 1998 and USDHHS, 2000). With the exception of Asian and Other in the third regression, ethnicity dummy variables were not significant.

The month dummy variables in the first equation in Table 7 were all negative (with April 2005 captured in the positive intercept). Furthermore, comparing the month coefficients, we observed a general increase with each subsequent month. This trend provided sound evidence that students were consuming more healthful foods than prior to the changes implemented in 2003-04 and that their choices became healthier the longer the program was in place. The lone exception was a decrease from November 2003 to April 2004. A possible explanation is that students were initially very excited about the new program in Hopkins in November 2003, but by April the excitement had worn off and some students slipped back to eating less healthful foods, before the positive trends toward healthier eating became firmly established.

Similarly, in the second equation, Improved (the linear time trend) was significant and positive. This reinforced the evidence that there was a significant improvement in the healthiness of the food choices made by students in the Hopkins High School, which coincided with the changes implemented by Royal Cuisine over this time period.

In the third equation, the coefficient for Asian was positive and significant at the 10 percent level, while the interaction variable Improved*Asian was negative and significant. This combination suggests that although Asians might have made healthier choices than whites (the omitted variable), the improvement in RHI for Asian students was less dramatic. The variable Improved*Other was also negative and significant, which implies that the food choices of Native Americans, Pacific Islanders, and Hispanics improved less. It is important to stress that these interaction variables do not imply that minority students experienced a decline in their ***RHI***

scores; rather because Improved was also positive, it suggests that the healthiness of their choices improved, but less dramatically than that of white students.

The last interaction term, Improved*Male, was positive and significant, suggesting that males had a greater improvement in the healthiness of their choices than females over the time period (but not that females saw a decrease in *RHI*). Recall that Female was positive and significant in every specification. This suggests 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. It is therefore very encouraging that males saw an improvement in their *RHI* measure after the innovations in Hopkin's school feeding program.

Relative Healthiness Estimation for 2004-05

In this case the estimation of *RHI* (and corresponding Expenditure) was calculated for 2004-2005 only. Recall from the Data section that during this school year the entrée purchased with a reimbursable meal was contained in the data and could be rated for healthiness. For this reason, we estimated this year separately, constructing the dependent variable under the assumption that a month is counted for student *i* if he or she purchases at least two à la carte items or a meal on at least ten days during that month. As before, if the student met these criteria, that student's first ten days with such purchases were used. There were 477 students appearing at least once in the sample.

Table 8 presents the results for the random-effects estimation with *RHI* as the dependent variable. Interaction terms with the "Improved" variable were not included because the time period considered was only two months. As seen in Table 8, by including full (reimbursable) meals in the calculation, the previous positive relationship between Expenditure and *RHI* no longer held. Meals during the 2004-2005 academic year generally received high healthiness

ratings and meals were a relatively inexpensive alternative to à la carte lunches. This is further support for the success of Royal Cuisine in meeting its goals and supports the claim that eating healthier food need not be more expensive.

Again, Female was positive and significant, reinforcing the earlier finding that females made healthier food choices. Given the negative and significant coefficients, Blacks and especially Other minorities made substantially less healthy food choices than whites. This suggests that Royal Cuisine needs 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 Improved was positive and significant, the improvement in the overall healthiness of the school lunches eaten at the Hopkins High School continued over the 2004-2005 school year.

Conclusions

Promoting more healthy 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 real-life, real-time school cafeteria. This study analyzed students' consumption behavior in an actual high school cafeteria against a backdrop of major changes in its feeding program. Much of the study focused on factors which affected the healthiness of food choices made by students under Hopkins Royal Cuisine program. The insights gained can support policies that bring about improvements in school lunch programs elsewhere. If Hopkins experience is replicable in other school districts, we can anticipate some of the impacts based on our analysis of participation and consumption decisions. We believe that the evidence strongly supports the possibility of changes similar to those in Hopkins elsewhere in America.

Hopkins School District has dramatically revamped its school feeding program with a commitment to providing healthy and appealing food choices to students. After the new program was implemented, Hopkins experienced a significant increase in participation both for full reimbursable meals as well as among students regularly purchasing à la carte items. Students started eating healthier lunches. Moreover, the trend toward choosing healthier à la carte food choices strengthened the longer the Royal Cuisine 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. Not only were lunches healthier; students were actually spending less money on average to purchase them.

Consistent with previous studies, we found that teenage females tended to purchase relatively healthier foods compared to males. However, male students showed a greater improvement in the healthiness of the à la carte foods they ate than the females over the 2002-2005 period. That the new program was particularly effective at improving the consumption habits of young males was an especially noteworthy achievement. Improving the eating habits of adolescent males can have a profound impact on their health throughout their lives.

Minorities, with the exception of Asians, tended to eat less healthy lunches, when both the à la carte and reimbursable meals could be evaluated in 2004-2005. Moreover, the Royal Cuisine program was less successful at improving the healthiness of the minority students' à la carte food choices over the 2002-2005 period, with the exception of Blacks. Students receiving reduced-price and free meals were responsive to the incentive to eat the reimbursable meals and, as might be expected, purchased very few à la carte items. However, it was noteworthy that receiving a reduced-price or free meal had no effect on the healthiness of the lunches eaten, so that students from poorer families were eating no less well than other students.

Hopkins witnessed very positive reactions to its school lunch innovations among its high school students, showing that helping students develop healthy eating habits can be made a key part of the fight against obesity and improvement in life-long health. It also showed that positive behavioral changes in eating patterns are possible when the right reforms are implemented in a "closed" environment. This lesson could be extended to other institutional settings such as workplace cafeterias, college dormitories, nursing homes, military bases and the home.

Endnotes

[1] The changes analyzed are not an experiment in which controlled laboratory methods were utilized (Smith, 2005 and Smith, 1982). Rather, we analyzed the impact of a change in policy regime, using 2002-2003 (before the change) as a baseline, and followed the same students over time, utilizing data prior to, during and after the change. The study is thus what Smith calls a "nomoempirical" experiment, which "compares the effect of different institutions and/or environments on behavior", and an "heuristic" experiment, which "provides empirical probes on new topics" (Smith, 2005a, p. 11).

[2] The prices of a reimbursable lunch in 2002-2003, 2003-2004, and 2004-2005 were $2.05, $2.30, and $2.50, respectively.

[3] This is due to a number of factors. First, the cash registers used have a limited number of keys. Second, in order to serve a large number of students over a short time period, minimizing the number of keys hit shortens the time required for each student to stand at the register.

[4] Some items with low purchase frequencies do not have unique item numbers. This was the case for some beverage categories. Multiple 100% juice items, for example, fall under one item number but all had a rating of +1.

[5] In the case that $N_i^t = 0$ for student i, R_i^t is not calculated.

[6] The choice of ten days was somewhat arbitrary—summing over 5 days does not create as much variation in the constructed dependent variable as 10 days, and more than 10 days reduces 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. This specification is meant to capture the consistency with which a student chooses relatively nutritious foods that are, on average, under-consumed by the average person in this age group.

[7] Constraining this measure to the same days for all students results in a drastic reduction of students entering the analysis to come. Thus, for each student, we use the first ten days in which that student has an observed *Daily Average Rating.*

[8] It is important to emphasize that, while the food offerings have generally become more healthful over time, there are still foods available in the High School that received a rating of –1 for 2004-2005. There has been a steady increase in the mean RHI score, which will be discussed in section 7, but there were still students in 2004-2005 whose RHI value was –10. This is discussed in section 7.1 and summarized in table 4.

[9] In most cases, "Expenditure" equals the amount paid by the student for that time period. However, if meals are included in the analysis, students receiving free or reduced price lunch pay less than the Expenditure shown. In the case of students receiving assistance, Expenditure corresponds to the total value of foods purchased, but not necessarily the amount spent by the student.

[10] In accordance with the Human Subjects regulations at the University of Minnesota, positive identifiers such as names and addresses were truncated prior to our access being granted.

[11] Because the students are in the same grade, employing an Age variable would provide little insight. Recall that the random samples were drawn from the sophomore class for 2002-2003, juniors for 2003-2004, and seniors for 2004-2005.

[12] This is done when the number of students receiving free or reduced-price lunch is small, such as when only one month is considered.

[13] This choice is not trivial. Because we are trying to predict à la carte purchases, using Assisted could actually predict the failures perfectly, which causes the variable to be dropped in the Stata estimation. However, Unassisted is not a perfect predictor of successes (because some students receiving assistance do not purchase à la carte items regularly), so it is not be dropped in the estimation process.

[14] The unbalanced nature of this panel is also partly due to students moving, transferring schools, dropping out, and being held back, and unknown other reasons.

[15] The Breusch-Pagan Lagrange Multiplier test was used to test the null hypothesis that there are no random effects. There are two error terms assumed in random effects. The Breusch-Pagan Lagrange Multiplier Test tests the null hypothesis that $\sigma^2_u = 0$, or that there is no significant person-level error term; this was rejected with p-value 0.0000.

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Table 1. Demographic Data Summary

	Nov 2002	Apr 2003	Nov 2003	Apr 2004	Nov 2004	Apr 2005
Sample Size	535	546	527	528	530	490
Female	260	266	249	257	249	230
Indian	6	5	5	4	5	3
Asian	30	28	29	29	29	26
Hispanic	19	16	13	13	13	14
Black	42	29	38	28	38	34
Reduced	12	9	13	10	13	11
Free	42	30	40	40	40	37

Table 2. Logit Monthly Estimations for Lunch Participation Model

	Nov 2002	Apr 2003	Nov 2003	Apr 2004	Nov 2004	Apr 2005
Female	-.72562***	-.93687***	-.67267***	-.85523***	-.68648***	-.6968***
	(.2132)	(.1871)	(.1817)	(.1822)	(.1802)	(.1900)
Asian	.91367***	.42690	.03342	-.37052	.36294	1.16724
	(.3546)	(.3934)	(.3918)	(.3882)	(.3921)	(.7273)
Black	.18551	.53281	-.83483*	.09875	-.00621	1.2632***
	(.4205)	(.4278)	(.5011)	(.4846)	(.4275)	(.4969)
Other	.06747	-.10987	-.39165	-1.08843**	.36136	-.64764
	(.5035)	(.4607)	(.4985)	(.4739)	(.5052)	(.6205)
Assisted	1.74708***	1.31642***	2.41505***	1.22450***	1.14825***	.66274*
	(.3476)	(.4009)	(.5854)	(.4441)	(.3868)	(.3714)
Intercept	-1.69649***	-1.1197***	2.67352***	1.7351***	1.51770***	-.7568***
	(.1810)	(.4092)	(.5977)	(.4653)	(.3981)	(.3743)
Wald χ^2_5	52.55	40.60	32.53	35.23	29.80	33.98
Sample *n*	535	546	527	528	530	490

Note: Huber/White/Sandwich robust standard errors are given in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Other refers to Hispanic or Indian students; the two groups were combined because there were relatively few represented in each group in any given month.

Table 3. Logit Monthly Estimations for À la carte Participation Model

	Nov 2002	Apr 2003	Nov 2003	Apr 2004	Nov 2004	Apr 2005
Female	.13601	.10962	.49376**	.36102*	.27057	.13953
	(.2039)	(.1907)	(.2138)	(.2023)	(.1829)	(.1921)
Asian	-.59918	-.96462**	.09293	-.17997	.16493	-.32687
	(.4090)	(.4028)	(.4772)	(.4140)	(.4130)	(.6757)
Black	-1.41424***	-.61669	.28873	.31719	-.12676	-.07203
	(.4320)	(.4723)	(.5754)	(.5896)	(.4362)	(.5052)
Other	-.83650*	-.32985	.33464	.21147	-.02833	.36438
	(.4734)	(.4547)	(.5774)	(.5757)	(.4746)	(.5594)
Unassisted	1.99645***	2.08688***	3.09917***	3.05076***	1.85296***	2.36951***
	(.3917)	(.4504)	(.5109)	(.4851)	(.3770)	(.4325)
Intercept	-.89334**	-1.24047***	-2.13358***	-2.25026***	-1.55129***	-2.0110***
	(.3948)	(.4601)	(.5323)	(.4892)	(.3816)	(..4351)
Wald χ^2_5	51.18	38.98	49.82	49.91	31.06	32.39
Sample *n*	535	546	527	528	530	490

Note: Huber/White/Sandwich robust standard errors are given in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4. McNemar's Test Setup for Meal Participation Rate Change

	Eat Often '04	Not Often '04	
Eat Often '03	159	53	212
Not Often '03	116	183	299
	275	236	511

Table 5. Descriptive Statistics for *RHI* Specification 1 By Month

	Nov 2002	*Apr 2003*	*Nov 2003*	*Apr 2004*	*Nov 2004*	*Apr 2005*
RHI Mean	-0.962	-.604	0.991	0.576	2.137	2.748
RHI Std Dev	2.803	3.095	3.498	3.237	3.630	3.564
RHI Min*	-10	-10	-9	-10	-10	-10
RHI Max*	8.5	9.167	10	9.5	10	10
Exp. Mean**	41.443	35.697	33.289	28.670	26.575	28.913
Exp. Std Dev	17.586	15.801	14.254	11.846	10.758	12.039

* Min and Max refer to the minimum and maximum *observed* value of *RHI*, respectively.
**Here we abbreviate Expenditure as Exp.

Table 6. Discrete Independent Variables for *RHI* Specification 1

	*Total**	*Female*	*Indian*	*Asian*	*Hispanic*	*Black*	*Reduced*	*Free*
Nov 2002	312	158	2	12	6	10	1	9
Apr 2003	352	172	3	12	9	12	2	5
Nov 2003	311	165	2	13	8	9	3	0
Apr 2004	298	146	3	15	7	10	2	1
Nov 2004	282	142	1	16	9	14	5	4
Apr 2005	258	122	0	13	9	11	1	4
Unique**	527	265	4	26	13	25	7	14

* The total number of individuals in that month's calculations.
**Refers to the number of unique individuals in the model.

Table 7. Random Effects Estimations for *RHI* Specification 1

	Random Effects1	*Random Effects 2*	*Random Effects 3*
Expenditure	.01436 (.0057)**	.01584 (.0057)***	.01844 (.0057)***
Female	1.14673 (.2379)***	1.1762 (.2396)***	2.28918 (.3479)***
Asian	-.41228 (.5479)	-.38988 (.5518)	1.63338 (.8822)*
Black	-.27956 (.6194)	-.28090 (.6239)	-.80665 (.9534)
Other	-.49297 (.6374)	-.51056 (.6420)	1.30014 (.9917)*
Reduced	-.67114 (.8046)	-.68996 (.8083)	-1.12964 (.9278)
Free	-1.21736 (.9243)	-1.18282 (.9297)	-.84453 (.8044)
Nov_2002	-3.95576 (.2347)***	--	--
Apr_2003	-3.43083 (.2207)***	--	--
Nov_2003	-1.99956 (.2216)***	--	--
Apr_2004	-2.26302 (.2228)***	--	--
Nov_2004	-.75465 (.2241)***	--	--
Improved	--	.78720 (.0412)***	.65811 (.0566)***
Improved*Asian	--	--	-.54856 (.1855)***
Improved*Black	--	--	.17320 (.2100)
Improved*Other	--	--	-.53241 (.2166)**
Improved*Male	--	--	.33501 (.0757)***
Intercept	1.87068 (.2878)***	-3.0234(.3283)***	-3.79341 (.3593)***
Rho	.44974	.45064	.45436
Wald χ^2	448.45	414.15	453.47
R-Sq Within	.2199	.2046	0.2209
R-Sq Between	.1456	.1390	0.1502
R-Sq Overall	.1735	.1647	0.1760

Note: Standard errors are given in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Rho denotes the fraction of variance that is due to u_i, the individual disturbance term. Recall this is an unbalanced panel; there are 527 students appearing *at least once* in this sample.

Table 8. Regression Results for 2004-2005 *RHI* Specification 2

	Random Effects
Expenditure	-.01074 (.0129)
Female	.54355 (.3147)*
Asian	-1.10089 (.7024)
Black	-1.50055 (.6104)**
Other	-3.34868 (.7743)***
Reduced	.93574 (.9453)
Free	-.36825 (.5863)
Improved	1.57134 (.2096)***
Intercept	2.01909 (.6336)***
Rho	.46588
Wald χ^2_8	90.82
R-Sq Within	0.1427
R-Sq Between	0.0893
R-Sq Overall	0.0905
Sample Size	477

Note: Standard errors are given in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Improved in the case of a two-period estimation is equivalent to using a month dummy for either month and adjusting the intercept term accordingly. Recall that Rho is the fraction of variance that is due to u_i, the individual disturbance term.