

Data Analytics for Societal Challenges: Understanding Student Participation in the National School Lunch Program

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Abstract

Record numbers of children experience hunger in the United States. For many children, meals provided by schools are the only reliable access to food. The COVID-19 pandemic exacerbated an already dire problem due to school closure. Over 50% of children in the United States qualify to receive free or reduced-price meals. However, each school district struggles with understanding the factors that affect student participation in the free or reduced-price national lunch programs. Each school district has its patchwork of disparate information systems and processes that makes it difficult to address how best to help a child who may be experiencing food insecurity.

The purpose of this study is to determine factors that influence meal participation of middle and high school students in one of the largest school districts in the United States and to provide actionable insights to decision makers to help them improve their outreach to disadvantaged students.

Keywords: data analytics, logistic regression, childhood hunger, food insecurity, school lunch programs

1. INTRODUCTION

Information Systems (IS) research is interdisciplinary in nature. In recent years, there have been increasing calls in top IS journals to address and tackle societal challenges using analytics and information systems (Ketter et al., 2020; Majchrzak et al., 2016). Societal challenges that IS researchers have addressed include infant mortality in India (Venkatesh et al., 2016), human rights and political injustice (Selander & Jarvenpaa, 2016), designing cost-effective telemedicine camps for underprivileged individuals (Li et al., 2020), and financial intermediary misconduct (Lausen et al., 2020).

Food insecurity and childhood hunger are societal challenges experienced globally. The COVID-19 pandemic made this challenge much worse. According to the latest United Nations (UN) State of Food Security and Nutrition report, global hunger numbers rose to 828 million in 2021 with an estimated 45 million children under the age of five experiencing wasting, which is the deadliest form of malnutrition (United Nations, 2021). Children in developed as well as developing countries face food insecurity.

Factors that contribute to hunger include mental and substance abuse, family violence, limited social support, residential instability, homelessness, housing subsidies, emergency

food program use, and participation in publicly funded programs (Wehler et al., 2004).

School districts in the US receive federal reimbursement per meal served when they participate in the National School Lunch Program (NSLP), which is a publicly funded program. Meals that schools provide are the only dependable access to food for many US children, of whom over 50% are eligible for Free and Reduced-price (F&R) meals (National Center for Education Statistics, 2021). School districts struggle to understand the factors affecting participation in the school lunch programs.

This paper aims to gain a greater understanding of the factors that impact meal participation by analyzing data at one of the largest school districts in the US. This school district has 126 schools and programs with an average daily enrollment of approximately 46,000 students. Out of the 126 schools, 81 schools participate in the NSLP that serves approximately 19,000 school lunches per school day. This school district's 18 neighborhood secondary schools (middle and senior high) had an enrollment count of 17,445 as of April 1, 2019 and served an average of 6,096 NSLP meals per day during the same school year.

Section 2 provides the background of our research problem and the framework we have used to formulate our research problem. Section 3 includes a detailed discussion of the methodology we have used in our paper. Section 4 includes results and discussion. We conclude our paper with Section 5 that provides limitations as well as guidance for further studies in this important topic.

2. BACKGROUND

Studies have shown that child nutrition programs contribute to improved student health (Gundersen et al., 2012), school attendance, and test scores (Bartfeld et al., 2019). The school district receives federal reimbursement per meal served through NSLP. Such meals are often referred to as reimbursable meals. Many lunches are served at low or no cost via F&R meal benefits (*National School Lunch Program*, 2020). Local Education Authorities (LEA) use household size and income guidelines to determine F&R eligibility. All students in a household become categorically eligible if a household applies and provides documentation of receipt of Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance for Needy Families (TANF), or Food Distribution Program on Indian

Reservations (FDPIR). Foster, homeless, migrant, runaway students, and Head Start program enrollees, are categorically eligible for F&R meals (*Determining Eligibility for Free and Reduced Price Meals and Free Milk in Schools*, 2020).

Students may also become eligible through Direct Certification. LEAs approve Directly Certified (DC) students for free meals when state or local agencies send documentation of categorical eligibility. LEAs may make use of the Community Eligibility Provision (CEP) at schools or groups of schools with high poverty rates. All students at CEP schools eat meals at no-cost and families do not need to submit a household application for F&R benefits (*Determining Eligibility for Free and Reduced Price Meals and Free Milk in Schools*, 2020). During both the 2017-2018 and 2018-2019 school years, 35 schools offered no-cost meals through CEP. Schools that do not elect CEP or another special reimbursement provision, meaning that they collect traditional F&R price meal applications and charge students at the free, reduced, or full-pay meal price, are called pricing schools.

The passage of the Healthy Hunger Free Kids Act of 2010 (HHFKA) further enhanced nutritional standards of child nutrition programs, including NSLP. School Food Authorities (SFA) were required to increase offerings of fruits, vegetables, whole grains, and low and non-fat fluid milk and to reduce sodium and eliminate trans fats in school meals (*Healthy Hunger Free Kids Act of 2010*, 2010). Nationally, NSLP participation has decreased each year from school year 2011-2012 through 2018-2019 (School Nutrition Association, 2019); however, enhanced nutrition standards have not resulted in decreased participation (J. F. W. Cohen et al., 2016; J. Cohen & Schwartz, 2020). Parental perception of nutrition is another factor used to gauge the impact on NSLP. This is a key factor in participation and it has not significantly changed since the implementation of the HHFKA (Martinelli et al., 2020).

Student participation in meal programs declines as grade level progresses, this is consistent both at a national and local level. At the national level, usual participation (consumption of three or more NSLP meals per week) of elementary, middle, and high school students was 67.8%, 58.0%, and 46.5% respectively during the 2014 – 2015 school year (Fox et al., 2019). The school district's estimated average daily participation rate (average daily participation divided by average daily Enrollment) during the 2018 – 2019 school year to be 50.9%, 46.4%, and 23.0% of

elementary, middle, and high school students, respectively. Table 1 presents the school district’s participation rate by eligibility.

Eligibility	Enrollment	ADP	ADP(%)
Ful Pay	9037	1073	11.90%
Free	8723	4775	54.7%
Reduced	530	248	46.80%
Total	18290	6096	33.33%

Table 1: Enrollment and Average Daily Participation (ADP), SY2018-2019

Existing literature indicates that eligibility for F&R meals is a dominant factor influencing participation; however, no study was found which separated eligibility factors categorically. (Edens et al., 2018; Gleason, 1995; Mirtcheva & Powell, 2009). Stigma, a negative association of students who participate in school meal programs, also has been shown to have an adverse impact on participation, including for students who qualified for free meals (Mirtcheva & Powell, 2009). We are not aware of any study that used categorical eligibility reason such as SNAP or TANF in lieu of eligibility status (free, reduced, or pai).

The school district provided Point-of-Sale (POS) timestamped transaction reports, menu and food production records, nutritional analysis, and daily enrollment reports. The transaction data included a coded student identification number that could be linked to daily enrollment data including F&R eligibility and categorical reason. The school district also provided general information about the 18 secondary schools, including the location and locally defined geographic region. The study focuses on the school district’s 18 neighborhood secondary schools where participation rates are lower in comparison to those at elementary schools. Additional data were included in the model to enhance the value of the model as a business analytic tool, these variables included the type of cuisine being served, whether the same student consumed a breakfast meal on the same day, and local weather data.

Students join a queue to be served lunch; the district opens between two and eight queues depending on the size and floor plan of the school. Once the students arrive at the front of the queue, they select their meal, and their meal is recorded in the POS system generating a timestamp. Since waiting time can adversely affect consumer repurchases and sentiment (Law et al., 2004), waiting time data was sought for this model. The school district does not measure the amount of time that a student spends in the queue, however, time between transactions was used to gauge overall speed and efficiency of the operation.

Weather data were included because the city in which the school district is situated experiences annual snowfall and a wide temperature variation throughout the year. Weather data was included in this study as a matter of business analytics. Of interest was whether inclement weather was a positive or negative influence on likelihood to participate. Students may prefer to remain on campus due to adverse conditions; conversely, students may not attend school at all, therefore reducing total participation. No prior research on the impact of weather on school meal participation was found and little was found relating to food service sales in general. At least one study has suggested that weather does impact food service sales (Bujisic et al., 2017). The study provides some merit to the potential that weather may be an influencing factor of NSLP participation.

The purpose of this study was to examine the factors that influence participation of secondary students in the NSLP and produce a business analytic model that provides a greater understanding of the factors that are most influential in a student’s decision to consume a NSLP meal. The study demonstrates that the reason for which a student is eligible for F&R meals is a substantial influence in the student’s likelihood to participate in the school meal program; students from the most vulnerable households to food insecurity, those receiving SNAP and TANF benefits, are substantially more likely to participate. Furthermore, students eligible for F&R meals exhibit different preferences than do full-pay students.

3. METHODOLOGY

Logistical regression was performed on transaction and enrollment detail data provided by the school district. Daily weather data was obtained from the National Climate Data Center. The data series from the city’s International Airport was used as it had the most consistently available dataset.

Institutional Review Board (IRB) approval of Human Subject Research was granted by expedited review from the university IRB after the school district reviewed and approved the release of data records and data de-identification method. Gender and ethnic data were not included in the data request out of an abundance of caution to avoid creating a personally identifiable dataset.

Database

Enrollment data included student ID (de-identified and coded), student age (in whole rounded months), the student’s current grade

level, school in which the student is enrolled, F&R eligibility status and reason, direct certification status and reason, and meal account balance. Enrollment data spanned from September 12, 2017 through May 22, 2019. There were 5,804,770 records from 23,864 distinct students.

Production records included menu and line-item detail of quantity prepared, served, and leftover each day at each school for NSLP reimbursable meals. Production records include an identifier of whether each line item is considered an entrée, side, or milk as determined by the school district's menu planner. If leftovers from a previous day were served, the leftovers were listed as a separate line item in the production record. Researchers categorized each entree by type of cuisine; the category names were selected from Google My Business Location Categories (Google, 2020) into a `hascuisine_TYPE` Boolean (1 = True, 0 = False) variable. Production data were aggregated by school, day, and meal period. The `hascuisine_TYPE` variable was aggregated using OR logic, such that if a single line item included a particular cuisine style, the aggregated result was recorded as 1.

Nutritional quality was scored using the Healthy Eating Index (HEI) 2015 score. The HEI-2015 is a measure of dietary quality that aligns to the Dietary Guidelines for Americans (DGA) resulting in a score of 0 to 100 based upon 13 parameters and is proportional to 1,000 kcal of energy making the score appropriate for measuring quality of any menu situation or age group (Krebs-Smith et al., 2018). The HEI-2015 produces reliable results for examination of dietary quality (Reedy et al., 2018). No records included Added Sugar, a 10-point parameter, thus, all HEI scores are reported on a modified scale of 0 to 90 referred to as the HEI-90. HEI-90 for each school, day, and meal was calculated as the summed product of the number of servings by the HEI criteria data. The 25th, 50th, and 75th percentile of HEI-90 scores were 44.3, 46.8, and 51.0 respectively.

Mean Time Between Transactions (MTBT) is a measure of waiting time calculated as a weighted mean time between two sequential POS transactions. Transaction times equal to or greater than six minutes were excluded since this likely represented time between meal periods or temporary line closures. The 25th, 50th, and 75th percentile of MTBT were 16.9, 20.9, and 24.6 seconds. A lagged version of MTBT was created to factor for repurchase behavior. `MTBT_5d` represents the weighted average of the current operating day and the five previous operating

days. If one or more of the five previous days were in a previous school year, the date was excluded.

Weather data was accessed from the National Climate Data Center. The measurement station at the city's international airport had no missing values. Low temperatures during the study period ranged from -7°F to 55°F, high temperatures ranged from 6°F to 70°F. Only low temperatures were used in the model as low and high temperature have a high degree of correlation and low temperature generated a lower Akaike information criterion (AIC), a measure used to determine the quality of a parameter in a logistic regression. Precipitation during the study period reached a maximum of 0.72 inches and snowfall a maximum of 7.8 inches.

Analysis

We built logistical regression models predicting the likelihood that a student would participate in the NSLP. We hypothesized that each of the factors we collected would have a significant relationship with likelihood to participate. We were unable to find any published studies that also utilized transaction-level detail to assess factors affecting school meal participation, so we propose a novel set of parameters for predicting likelihood of a student to participate in the NSLP. Previous literature indicates free and reduced-price meal eligibility is the leading factor influencing school meal participation. We created a multi-class parameter called `pricereason`, expanding upon eligibility by including reasons such as direct certification.

Data were merged, imported to SAS 9.4, and divided into training (70%) and validation (30%) data sets by Stratified Random Sampling (SRS). Confounding parameters were resolved by performing comparative logistic regression models, the parameter that generated the highest Akaike information criterion (AIC) was removed. The resulting preliminary logistical model was refined by using SAS' backward selection procedure with 95% confidence (`SLEXIT=.05`).

The training and validation datasets were subdivided into smaller data sets of CEP and Pricing schools, DC students, DC students at CEP schools, DC students at pricing schools, F&R eligible students at pricing schools and paid students at pricing schools. We further divided the datasets by the school district's geographic regions. Model performance was assessed by generating a Receiver Operator Curve (ROC) and calculating the Area Under the Curve (AUC) of the model using the validation data sets.

4. RESULTS AND DISCUSSION

Table 2 displays three of the logistical regression models. The full model included all students and schools. The AUC of the validation data set was .8249. The DC Student model only included DC students and the Full-pay student model only included students who were not qualified for F&R meals by any means.

F&R Eligibility

Our findings are consistent with previous studies, which show that F&R eligibility is the dominant factor influencing NSLP participation. Delimiting F&R eligibility further by direct certification category provided insightful results; of DC students, those certified from SNAP or TANF were 8.07 times more likely to participate in lunch than were full-pay students while students who were Directly Certified by other means were 6.18 times more likely to participate than full-pay students were. Students certified for free meals by application were 7.44 times more likely to participate than were full-pay students; students at CEP schools who were not Directly Certified were 6.88 times more likely; and those certified for reduced-price meals were 6.65 times more likely. Within pricing schools, the rank order of greatest to least odds ratios changes with application-based free certifications becoming highest odds ratio, then reduced, Directly Certified SNAP and TANF, followed by other Directly Certified students.

The results indicate categorical differences within free eligibility have distinguishable outcomes. Ambiguity exists between the full model and the model derived from pricing schools only; universal feeding may play a substantial role in the variance between the two models. CEP schools widely advertise no-cost meals for all, while DC students may be unaware of the availability of no cost meals at pricing schools. LEA's must notify a student's parent or guardian if the student is eligible for F&R meals (*Determining Eligibility for Free and Reduced Price Meals and Free Milk in Schools*, 2020); however, there is no direct mechanism by which LEAs could determine if a parent read and comprehends the notice.

Of DC Students, those certified by SNAP or TANF consistently have higher odds ratios in comparison to those certified by another category where likelihoods are relative to full-pay students. SNAP and the state TANF recipients must pass income and asset tests to qualify for benefits which make both programs equally, if not more, restrictive as F&R income eligibility guidelines

(*Determining Eligibility for Free and Reduced Price Meals and Free Milk in Schools*, 2020).

Same Day Breakfast Participation

Students who participated in the School Breakfast Program (SBP) were 4.87 times more likely to subsequently participate in NSLP in the same day compared to students who had not participated in the SBP. Across all models, breakfast participation was associated with higher likelihood of NSLP participation. Full-pay students who participate in school breakfast are 14.34 times more likely to participate in NSLP. It is difficult to describe this as a causal or coincidental relationship without further analysis.

Grade Level

Grade level progression was found to decrease NSLP participation; for each increase in grade level, the odds ratio was 0.75 that a student would participate. Directly Certified and F&R eligible students exhibited similar results while full-pay students were slightly lower (odds ratio = 0.70). Across regional models, one region, exhibited a slightly higher trend than other regions with an odds ratio of 0.81 (all schools are pricing schools with proportionally lower F&R eligibility rates). The school district's high schools are open campuses and students are free to leave during their lunch period. Anecdotal data shows that there are fewer restaurants close to one of the regional secondary schools in comparison to other school district regions. These findings suggest that grade level may act as a proxy for competitive food service; however, we were unable to collect adequate competitive food service data to state this conclusively.

Mean Time between Transaction

An increase of one second to the five-day lagged MTBT resulted in a likelihood to participate 0.99; this result was nominal but statistically valid $p < .001$. MTBT had unexpected performance across models, it was at or less than 1 for DC and F&R eligible students, as well as at CEP schools, but slightly above 1 at pricing schools and 1.02 among full-pay students. Because the ratio is nominal in each of the models, it is difficult to discern why full-pay students behave differently than F&R eligible students; perhaps one reason is that it is of less importance than are other factors such as cuisine choice and price.

Full-pay students may be exhibiting characteristics of social learning behavior, referred to as *herding*. Social learning occurs when one individual observes others' behavior and repeats (cascades) the same behavior. Social learning has many pragmatic benefits and has been observed in laboratory experiments as well

as in consumer behavior (Bikhchandani et al., 1998). Students likewise may be making meal participation choices based upon their peers' decisions, which would drive up line queues and reduce transaction speed.

Operating Cycle

In general, students were less likely to participate in the second or subsequent weeks of the month when compared to the first week. This was true, even among DC students, many of whom are qualified by SNAP or TANF. People receiving SNAP and TANF benefits receive benefits via EBT debit card, which is reloaded on the first day of each month. We had expected to see a decline in likely participation on the first week of the month with subsequent weeks having an odds ratio of 1 or greater.

There were nominal, yet measurable variations, in NSLP participation depending upon the day of the week. NSLP participation was more likely on Tuesday and less likely on Friday when compared to Monday. This pattern was generally consistent with the notable exception of full-pay students who were more likely to participate on Thursday and Friday (odds ratios of 1.02 and 1.04 respectively). Since the model is based upon enrollment rather than attendance, day of the week characteristics may proxy for attendance to some degree.

Nutrition

HEI-90 is a nominal but statistically significant parameter; the odds ratio resulting from a one-point increase in HEI-90 is 1.002. Directly Certified and F&R eligible models also resulted in a nominal parameter with odds ratios of 1.007 and 1.003 respectively; full-pay students were 0.997. The results confirm that nutritional standards of the HHFKA do not adversely influence the nutrition program overall; however, it may adversely affect full-pay students.

Cuisine Offered

Cuisine offerings that increased likelihood of participation were Italian, Asian, Bakery, and Breakfast; those that decreased likelihood were Salad, Seafood, Pizza, BBQ, Hamburger, and Chicken. Among full-pay students, Chicken, Hamburger, and Pizza increased likelihood of participation, DC students and F&R eligible students were consistent with the full model, although several cuisine parameters of the F&R eligible student model were insignificant ($p > .05$). Overall, student preferences align with less frequently offered menu cuisines while full-pay students align with frequently offered cuisine. Italian, Asian, Bakery, and Breakfast cuisine choices appeared in 14, 544, 250, and 516 of the

5,675 menus reviewed. Chicken, Hamburger, and Pizza each appeared in 2,805, 718, and 3,624 of the same menus. This data indicate that menus are aligned to the preferences of full-pay students who comprise 18% of daily meals served.

Food boredom should also be taken into consideration as a potential factor resultant in the clear differentiation of full-pay versus F&R student preferences. F&R eligible, DC, and CEP students comprise 82% of average daily participation. Full-pay students' lower participation and presumed higher income indicate that such students have access to a wider variety of alternative food sources on an ongoing basis; these results portray full-pay students as more responsive to food boredom than other students. Time preferences are a means of measuring food boredom but are difficult to measure outside of a laboratory environment (Moskowitz, 2000).

Weather

Precipitation, snowfall, and daily low temperature were found to be the most reliable indications of weather impact on meal participation. Precipitation was found to increase likelihood of participation (odds ratio=1.10 for each additional inch) while snowfall had the opposite influence (odds ratio=0.98 for each additional inch of snowfall). Temperature increases also decreased likelihood of participation (odds ratio=0.999 each one-degree Fahrenheit increase in daily low temperature). Similar outcomes were seen across all models; however, additional information is needed to determine if there is a causal relationship between precipitation and participation. Snowfall may act as a proxy for attendance, as inclement weather can create adverse driving conditions, potentially reducing school attendance.

5. CONCLUSIONS

Food insecurity is a major issue globally. Information Systems researchers are increasingly using data analysis to tackle societal challenges. In this paper, we use data analysis to provide actionable insights to decision makers to help them understand factors that influence meal participation of school students.

The primary findings of our study are that F&R eligibility is the most influential factor of NSLP participation, use of F&R eligibility category improves analytical value, and students certified for F&R meals display contrary preferences to full-pay students. Additionally, we found students who are directly certified through SNAP or TANF were more likely to participate at a CEP school

than at a pricing school. Previous school meal participation studies have used aggregated and survey-based data sources and collection methods; this study is the first to develop a model that is based on transaction and student-level data acquired directly from the LEA's information systems.

Eligibility for F&R meals is the most influential factor in meal participation. This finding is consistent with previous studies; however, we found eligibility category to be of significance in distinguishing participation likelihood. In general, we found that of DC students, those certified for SNAP and TANF were consistently more likely to participate than those certified by another category. Students certified by an application were more likely to participate than students who were qualified because their school participated in CEP. We also discovered an anomaly that SNAP and TANF DC students' propensity to participate in NSLP was much lower at pricing schools than at CEP schools, indicating that stigma may play a role in meal participation.

In general, we found that nutritional quality, as measured by the HEI-90 score, was a nominal indication of higher likelihood for participation. This finding is consistent with studies which have shown the nutritional standards enacted by the HHFKA have not adversely impacted participation. We found this was consistent for F&R eligible students; however, full-pay students were less likely to participate when healthier menus were offered.

Full-pay students exhibited an increase in likelihood to participate when a frequently offered cuisine type was offered and were also more likely to participate when waiting time increased. On the contrary, F&R eligible students showed a preference toward less frequently served cuisines and shorter waiting times. These findings may be the result of direct cuisine and nutritional preferences, the result of food boredom, or a combination of both.

A concern that arises from the cuisine and nutrition parameters is that menu design and selection may be driven by full-pay students who comprise about 45% of the school district's secondary student population. Full-pay students' participation is only 12%; in comparison, F&R eligible and CEP student participation rates are near or above 50%. One key challenge in accurately collecting and analyzing this data is the ability to determine whether survey and other customer engagement mechanisms are reaching a true representative sample of this student.

Utilizing transaction and student-level data provides many data quality and analytical benefits in comparison to aggregated or survey-based data collection methods. Perhaps most important is the ability to directly model dependent variables to an individual, determinable, verifiable outcome (participation) by logistical regression. Our dataset can be easily segregated by a population characteristic such as F&R eligibility, eligibility category, or region to better analyze and interpret data. Separating transactions of F&R eligible, directly certified, and full-pay students produced meaningful results. Additionally, utilizing transactional data provides a truer representation of the entire student population than survey or voluntary data collection methods where many students may be unwilling or unable to respond. SFAs or LEAs could apply similar methodologies to develop a model specific to some or all schools within their district, this methodology can be applied in districts with any combination of pricing or CEP schools.

Developing a regional, state, or national model from data from multiple SFAs would be more challenging. Meal participation data reported to the USDA is aggregated, often at multiple levels, between the school and SFA, SFA and State Agency, and State Agency and USDA's Food and Nutrition Services Regional Offices (FNSRO). There are no requirements that SFAs maintain electronic transaction records in a specific format (*Request for Information: Software Vendors of State and Local Management Information Systems (MIS)*, 2016). Data pertaining to NSLP operations, such as production and nutritional analysis records, are maintained only by the SFA, like transaction records there is no requirement to maintain them in a standardized format (*National School Lunch Program*, 2020). Therefore, these limitations would make it difficult to build an expanded regional or national model with existing public data sources.

Limitations

Previous participation studies considered availability of competitive foods as a negative factor of participation. We had attempted to acquire data that included the number of quick service restaurants and their proximities to school campuses. Nonetheless, we were unable to find a suitable method of integrating currently available competitive food data as a factor on a transactional or daily basis. Additionally, data on competitive food sales within schools is not readily available. The increasing prevalence of food delivery services raises additional challenges for future research as such services reduce the

traditional customer barriers of location and convenience.

Previous literature indicates that key influential factors of meal participation include socioeconomic variables such as race, gender, household income, and parents' education. We requested only the student information that was available in the school district's meal eligibility and accountability system to mitigate potential privacy concerns. We also declined to request daily attendance due to both privacy and practical purposes; the school district's attendance data is per class period and it would be difficult to discern whether an attendance report indicated if a student was present during the lunch period.

Further Study

Opportunity for further study exists, particularly focusing on the behavioral differences between full-pay and F&R eligible students. Differences in preferences relating to cuisine, nutritional quality, and waiting time indicate that additional factors influence students' decisions. Additional factors to consider include food boredom, social learning, access to, and availability of alternative food sources, and social stigma. If program administrators focus on improving participation among primarily F&R eligible students, this potentially increases the stigma that school meal programs are for low-income families. Conversely, focus on full-pay student participation overlooks a vulnerable population for which school nutrition programs are intended to serve. Thus, research, which enables program administrators to improve participation for both F&R eligible and full-pay students, is important to ensure continued program success.

We found evidence that stigma may alter DC students' propensity to participate when comparing CEP and pricing schools. This finding was inconclusive since we did not include a measure of stigma. We found only one study that had made an attempt to measure the impact of stigma on meal participation (Mirtcheva & Powell, 2009). Further study would allow future researchers to better measure stigma and enable program administrators to better design programs that de-stigmatize school meal participants.

This study produced a model that quantifies the factors influencing lunch participation in secondary schools. The methodology resulted in a model that has operational and analytical benefits for the school district and other SFAs and potentially enables program administrators to better estimate how many, and specifically which

students are likely to participate on a given day and for a set of circumstances.

Administrators may use the results from this model, or a similarly constructed model, to deliberately adjust menus, nutritional specification, and manage operational characteristics resulting in greater appeal of meal program to students. Administrators and other decision makers can use the results from this model for outreach efforts to help disadvantaged students and to combat food insecurity.

9. REFERENCES

- Bartfeld, J. S., Berger, L., Men, F., & Chen, Y. 2019. "Access to the School Breakfast Program Is Associated with Higher Attendance and Test Scores among Elementary School Students," *Journal of Nutrition* (149:2), Oxford University Press, pp. 336–343. (<https://doi.org/10.1093/jn/nxy267>).
- Bikhchandani, S., Hirshleifer, D., & Welch, I. 1998. "Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades," *Journal of Economic Perspectives* (12:3), pp. 151–170. (<https://doi.org/10.1257/jep.12.3.151>).
- Bujisic, M., Bogicevic, V., & Parsa, H. G. 2017. "The Effect of Weather Factors on Restaurant Sales," *Journal of Foodservice Business Research* (20:3), Routledge, pp. 350–370. (<https://doi.org/10.1080/15378020.2016.1209723>).
- Cohen, J. F. W., Gorski, M. T., Hoffman, J. A., Rosenfeld, L., Chaffee, R., Smith, L., Catalano, P. J., & Rimm, E. B. 2016. "Healthier Standards for School Meals and Snacks: Impact on School Food Revenues and Lunch Participation Rates," *American Journal of Preventive Medicine* (51:4), Elsevier, pp. 485–492. (<https://doi.org/10.1016/j.amepre.2016.02.031>).
- Cohen, J., & Schwartz, M. B. 2020. "Documented Success and Future Potential of the Healthy, Hunger-Free Kids Act," *Journal of the Academy of Nutrition and Dietetics* (120:3), Elsevier Inc, pp. 359–362. (<https://doi.org/10.1016/j.jand.2019.10.021>).
- Determining Eligibility for Free and Reduced Price Meals and Free Milk in Schools. 2020. 7 C.F.R. §245. (<https://ecfr.federalregister.gov/current/title>

- 7/subtitle-B/chapter-II/subchapter-A/part-245). (<https://doi.org/10.1016/j.jand.2018.05.021>).
- Edens, D., Lopez, A., Kessler, L., & Burns-Whitmore, B. 2018. "Evaluation of the Factors Influencing Participation in the National School Lunch Program (NSLP) for Latino Students During Middle School and High School Years," *Californian Journal of Health Promotion* (16:2), pp. 11-21. (<https://doi.org/10.32398/cjhp.v16i2.2087>).
- Fox, M. K., Gearan, E., Cabili, C., Dotter, D., Niland, K., Washburn, L., Paxton, N., Olsho, L., LeClair, L., & Tran, V. 2019. School Nutrition and Meal Cost Study, Final Report Volume 4: Student Participation, Satisfaction, Plate Waste, and Dietary Intakes, (4:April). (<http://www.fns.usda.gov/research-and-analysis>).
- Gleason, P. M. 1995. "Participation in the National School Lunch Program and the School Breakfast Program," *American Journal of Clinical Nutrition* (61:1 SUPPL.). (<https://doi.org/10.1093/ajcn/61.1.213s>).
- Google. 2020. "Google My Business Locations Categories." (<https://docs.google.com/spreadsheets/d/10QhWFmHYhZI7FL7cQZUqkDkRbexPVthEIfp8ii bhA3s/edit#gid=1618773282>, accessed April 19, 2020).
- Gundersen, C., Kreider, B., & Pepper, J. 2012. "The Impact of the National School Lunch Program on Child Health: A Nonparametric Bounds Analysis," *Journal of Econometrics* (166:1), Elsevier B.V., pp. 79-91. (<https://doi.org/10.1016/j.jeconom.2011.06.007>).
- Healthy Hunger Free Kids Act of 2010. 2010. Pub. L. No. 111-296, 124 Stat. 3183. (https://fns-prod.azureedge.net/sites/default/files/PL_111-296.pdf).
- Ketter, W., Padmanabhan, B., Pant, G., & Raghu, T. S. (2020). Special Issue Editorial: Addressing Societal Challenges through Analytics: An ESG ICE Framework and Research Agenda. *Journal of the Association for Information Systems*, 21(5), 1115-1127. (<https://doi.org/10.17705/1jais.00631>).
- Krebs-Smith, S. M., Pannucci, T. R. E., Subar, A. F., Kirkpatrick, S. I., Lerman, J. L., Tooze, J. A., Wilson, M. M., & Reedy, J. 2018. "Update of the Healthy Eating Index: HEI-2015," *Journal of the Academy of Nutrition and Dietetics* (118:9), Elsevier Inc, pp. 1591-1602.
- Lausen, J., Clapham, B., Siering, M., & Gomber, P. (2020). Who Is the Next "Wolf of Wall Street"? Detection of Financial Intermediary Misconduct. *Journal of the Association for Information Systems*, 21(5), 1153-1190. (<https://doi.org/10.17705/1jais.00633>).
- Law, A. K. Y., Hui, Y. V., & Zhao, X. 2004. "Modeling Repurchase Frequency and Customer Satisfaction for Fast Food Outlets," *International Journal of Quality and Reliability Management* (21:5), pp. 545-563. (<https://doi.org/10.1108/02656710410536563>).
- Li, X., Rai, A., & Krishnan, G. (2020). Designing Cost-Effective Telemedicine Camps for Underprivileged Individuals in Less Developed Countries: A Decomposed Affordance-Effectivity Framework. *Journal of the Association for Information Systems*, 21(5), 1279-1312. (<https://doi.org/10.17705/1jais.00637>).
- Majchrzak, A., Markus, M. L., & Wareham, J. (2016). Designing for Digital Transformation: Lessons for Information Systems Research from the Study of ICT and Societal Challenges. *MIS Quarterly*, 40(2), 267-277. (<https://doi.org/10.25300/MISQ/2016/40:2.03>).
- Martinelli, S., Acciai, F., Au, L. E., Yedidia, M. J., & Ohri-Vachaspati, P. 2020. "Parental Perceptions of the Nutritional Quality of School Meals and Student Meal Participation: Before and After the Healthy Hunger-Free Kids Act," *Journal of Nutrition Education and Behavior* (000:000), Elsevier Inc. (<https://doi.org/10.1016/j.jneb.2020.05.003>).
- Mirtcheva, D. M., & Powell, L. M. 2009. "Participation in the National School Lunch Program: Importance of School-Level and Neighborhood Contextual Factors," *Journal of School Health* (79:10), pp. 485-494. (<https://doi.org/10.1111/j.1746-1561.2009.00438.x>).
- Moskowitz, H. R. 2000. "Engineering out Food Boredom: A Product Development Approach That Combines Home Use Tests and Time-Preference Analysis," *Food Quality and Preference* (11:6), pp. 445-456. ([https://doi.org/10.1016/s0950-3293\(00\)00016-1](https://doi.org/10.1016/s0950-3293(00)00016-1)).

- National Center for Education Statistics. 2021. "Number and percentage of public school students eligible for free or reduced-price lunch, by state: Selected years, 2000-01 through 2019-20," Digest of Education Statistics, Table 204.10 (https://nces.ed.gov/programs/digest/d21/tables/dt21_204.10.asp).
- National School Lunch Program. 2020. 7 C.F.R. §210. (<https://ecfr.federalregister.gov/current/title-7/subtitle-B/chapter-II/subchapter-A/part-210>).
- Reedy, J., Lerman, J. L., Krebs-Smith, S. M., Kirkpatrick, S. I., Pannucci, T. R. E., Wilson, M. M., Subar, A. F., Kahle, L. L., & Tooze, J. A. 2018. "Evaluation of the Healthy Eating Index-2015," *Journal of the Academy of Nutrition and Dietetics* (118:9), Elsevier Inc, pp. 1622-1633. (<https://doi.org/10.1016/j.jand.2018.05.019>).
- Request for Information: Software Vendors of State and Local Management Information Systems (MIS). 2016. 81 F.R 1599. (<https://www.federalregister.gov/d/2016-00504>).
- School Nutrition Association. 2019. "NSLP Participation Tracker." (<https://schoolnutrition.org/news/research/nslw-sbp-participation-tracking/>).
- Selander, L., & Jarvenpaa, S. L. (2016). Digital Action Repertoires and Transforming a Social Movement Organization. *MIS Quarterly*, 40(2), 331-352. <https://doi.org/10.25300/MISQ/2016/40.2.03>.
- UN Report: Global hunger numbers rose to as many as 828 million in 2021. (n.d.). Retrieved July 15, 2022, from <https://www.unicef.org/press-releases/un-report-global-hunger-numbers-rose-many-828-million-2021>.
- Venkatesh, V., Rai, A., Sykes, T. A., & Aljafari, R. (2016). Combating Infant Mortality in Rural India: Evidence from a Field Study of eHealth Kiosk Implementations. *MIS Quarterly*, 40(2), 353-380. <https://doi.org/10.25300/MISQ/2016/40.2.04>.
- Wehler, C., Weinreb, L. F., Huntington, N., Scott, R., Hosmer, D., Fletcher, K., Goldberg, R., & Gundersen, C. (2004). Risk and Protective Factors for Adult and Child Hunger Among Low-Income Housed and Homeless Female-Headed Families. *American Journal of Public Health*, 94(1), 109-115.

APPENDIX A
Logistic Regression Models

Parameter (Reference)		Full Model	DC Students	Full-pay Stu
Intercept		0.7024 ***	2.6060 ***	0.7070 ***
F&R Eligibility (Paid)	DC SNAP/TANF ^a	2.0887 ***	—	—
	DC Other ^b	1.8215 ***	—	—
	CEP Free	1.9289 ***	—	—
	Free (App) ^c	2.0074 ***	—	—
	Reduced	1.8952 ***	—	—
Week in Month (1)	2nd Week	-0.0070 *	0.0032	-0.0185 ***
	3rd Week	-0.0595 ***	-0.0555 ***	-0.0376 ***
	4th Week	-0.0469 ***	-0.0190 ***	-0.0869 ***
	5th Week	-0.0722 ***	-0.0700 ***	-0.0645 ***
Weekday (Monday)	Tuesday	0.0178 ***	0.0082	0.0127
	Wednesday	-0.0152 ***	-0.0273 ***	-0.0077
	Thursday	0.0001	-0.0042	0.0181 **
	Friday	-0.0178 ***	-0.0461 ***	0.0364 ***
Same Day B-fast (No)	Yes	1.5840 ***	1.5766 ***	2.6633 ***
Cuisine Offered (No)	Asian	0.0409 ***	0.0378 ***	0.0557 ***
	Bakery	0.0308 ***	—	0.0989 ***
	Breakfast	0.0157 **	-0.0309 ***	0.0679 ***
	BBQ	-0.0373 ***	-0.0710 ***	—
	Chicken	-0.0175 ***	-0.0391 ***	0.0119 **
	Hamburger	-0.0251 ***	-0.0384 ***	0.0309 ***
	Italian	0.3892 ***	0.6223 ***	—
	Mexican	—	—	—
	Pizza	-0.0455 ***	-0.0911 ***	0.0698 ***
	Sandwich	—	-0.0517 ***	0.1021 ***
	Seafood	-0.0495 ***	-0.0439 ***	-0.0974 ***
	Salad	-0.1031 ***	-0.1281 ***	-0.0634 ***
Continuous Variables	MTBT (5d) ^d	-0.0103 ***	-0.0289 ***	0.0167 ***
	HEI-90 ^e	0.0025 ***	0.0068 ***	-0.0025 ***
	Grade	-0.2825 ***	-0.2417 ***	-0.3507 ***
	Precipitation ^f	0.0976 ***	0.1436 ***	—
	Snowfall ^f	-0.0229 ***	-0.0279 ***	-0.0056 **
	Low Temp ^g	-0.0009 ***	—	-0.0008 ***

Table 2: Logistic Regression Models (All students, DC students, and Full-pay students)

*, **, and *** represent significance at p-value <.10, <.05, and <.01 respectively
 M-Dash (—) indicates not parameter is not statistically significant.

^a Directly Certified SNAP, TANF, and extended eligibility. ^b Directly Certified FDPIR, foster, homeless, migrant, and runaway. ^c Includes both income and categorical applications. ^d *Mean Time Between Transactions (seconds)*. ^e *Derived from the Healthy Eating Index (90-point scale)*. ^f *Measured in inches*. ^g *Measured in °F*.