A Comparative Analysis Model for Predicting the Impact of New York School Food Participation on SAT Performance

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This study investigates the relationship between the quantity of food provided by high schools and SAT scores for high school students in 32 districts located in New York just prior to the 2020 COVID-19 pandemic. This study specifically evaluated the correlation between student participation in school meal programs and student SAT performance. Investigating the correlation between student average daily participation (ADP) in school meals and SAT performance is important because studies indicate that nutrition is an important factor that can influence academic performance. Average daily participation in school meal programs is defined as the acceptance of meals by students offered by schools. I built a neural network training model and linear regression model based on the collection and normalization of data from 32 districts located in New York and examined the effect of the average quantity of food distributed by school cafeterias for breakfast, lunch, dinner, and snacks against scores for all SAT sections. While there are a variety of factors that can influence student SAT performance which can be further studied, this study demonstrated a positive relationship between the participation of students in cafeteria food, specifically breakfast and lunch, with higher SAT test results, concluding that schools in New York might want to consider making food more accessible to students on weekdays with the aim of improving student aptitude test performance.

Keywords: Academic performance, Food security, High schools, SAT scores

Introduction

It is well understood that access to food is an important factor that impacts academic performance[1]. However, school meal programs vary greatly by school, city, and state[2]. Some schools offer lunch only as part of the National School Lunch Program. Other schools offer breakfast, lunch, supper, and snacks. In 2017, the New York City school system made school meals free for all public school students regardless of income[3].

According to a research article by Kocak in the International Online Journal of Education and Teaching, a comprehensive review of 169 studies identified multiple factors impacting academic achievement, like socioeconomic status, family environment, and access to resources like food. While it is extremely challenging to study all the factors that impact SAT performance, I found the relationship between food access and SAT scores interesting. Rather than approaching this study from a broad correlation between food and academic performance, I was curious to understand if there was a discrepancy when it comes to SAT performance and quantity of food schools made accessible to their students. I approached this project with a simple thesis: How does access to food, specifically food served in high school cafeterias, impact a student's SAT performance? I believed the analysis would show a strong correlation between higher SAT scores and food access. This study concentrated on schools in New York City in 2019 before the COVID-19 pandemic, which was a time when SAT scores were required for college admission during a time when school meals were universally accessible to students.

Other research has indicated a positive correlation between nutrition and academic performance. For example, the study "Let Them Eat Lunch: The Impact of Universal Free Meals on Academic Performance" by Krista Ruffini demonstrated that student access to free school meals positively affected their academic success. Ruffini found that schools offering universal free meals saw improvements in test scores, more in math and reading than other subjects. The study supports the idea that having students that are well-fed can benefit academic achievement. Other research also supports this positive correlation[4].

The article "What Are the Benefits of Free School Meals? Here's What the Research Says" from the University of Illinois highlights the significant impact free school meal programs can have on students' well-being and academic success. Research cited in the article shows that access to free meals improves students' nutritional intake, reduces food insecurity, and can lead to better academic performance and behavior. Students who regularly receive free meals are more likely to stay focused in class and experience fewer health-related issues that can disrupt learning[5].

Methodology

I identified 32 school districts in New York City, which represents 533 high schools, and I gathered data on average SAT scores for each SAT section – Math, Reading, and Writing. I also researched the average amount of food distributed by the cafeterias in the 533 schools for breakfast, lunch, supper, and snacks. I populated a table with SAT scores for each of the 32 school districts and the average daily participation (ADP) for high school meals served.

In order to correlate the different datasets, I created a uniform dataset by converting school-level data for average SAT scores into district-level score data so that it aligned with the average ADP district-level data. I then developed a neural network trainable model and linear regression model using average quantity of food at breakfast, lunch, supper, and snacks (ADP) as the inputs and SAT scores for the Math, Reading, and Writing sections as the outputs. Linear regression assumes a linear relationship between the independent and dependent variables while neural networks can model complex, nonlinear relationships. The linear regression model showed a simpler result yielding a positive correlation between food access and SAT performance.

The neural network model I created finds the correlation between the different ADPs for each school district and scores for each SAT section. The model was created with 75 epochs. I used 80% of the data to train the neural network model and 20% to evaluate the accuracy of the model. My neural network model used a sequential structure and the layers consisted of a dense layer with 512 nodes. Another dense layer with 256 nodes was set with an activation of "relu". A third dropout layer was programmed with a value of 0.5, and two additional dense layers with 64 and 32 nodes were then programmed with "relu" activation. The neural network model generated a projected SAT score for each SAT section. You can access the code from the Appendix, which is at the end of this report.

I tried other neural network structures containing simpleRNN layers and batch normalization layers. However, with the addition of these layers came more data loss and inaccuracy in the model. I therefore withdrew structures containing simpleRNN layers and batch normalization layers from the final neural network model used to conduct the analysis. I also experimented using fewer and more nodes in order to evaluate the impact on accuracy and speed of neural network data processing. I struck a balance between accuracy and speed of the neural network model.

Using the linear regression model, I mapped the ADP and SAT test score variables to produce simple linear regression graphs. The code and data table demonstrating the neural network model and linear regression model are publicly accessible in the GitHub repository.

Results

The results of the research showed that the students who participated more in breakfast, lunch, and supper at school achieved higher average SAT scores.

For breakfast, this was demonstrated to be true for each section of the SAT – Math (Table I), Reading (Table II), and Writing (Table III). Of the 32 school districts studied, the data ranged from a Math SAT score of 355 with 4,887 breakfast ADP to a score of 594 with 13,700 breakfast ADP. For Reading, it ranged from an SAT score of 367 with 3,867 breakfast ADP and 578.5 with 13,008 breakfast ADP. For Writing, it ranged from an SAT score of 365 with 3,867 breakfast ADP to 574 with 13,008 breakfast ADP.

The analysis of lunch showed the data ranged from a Math SAT score of 355 with 12,486 lunch ADP to a score of 594 with 31,451 lunch ADP (Table IV). For Reading, it ranged from an SAT score of 367 with 8,413 lunch ADP and 578.5 with 33,083 lunch ADP (Table V). For Writing, it ranged from an SAT score of 365 with 8,413 lunch ADP to 574 with 33,083 lunch ADP (Table VI).

The analysis of supper showed the data ranged from a Math SAT score of 355 with 1,249 supper ADP to a score of 594 with 2,298 supper ADP (Table VII). For Reading, it ranged from an SAT score of 367 with 1,183 supper ADP and 578.5 with 3,815 supper ADP (Table VIII). For Writing, it ranged from an SAT score of 365 with 1,183 supper ADP to 574 with 3,815 supper ADP (Table IX).

The analysis of after school snacks showed the data ranged from a Math SAT score of 355 with 2,584 after school snacks ADP to a score of 594 with 2810 after school snacks ADP (Table X). For Reading, it ranged from an SAT score of 367 with 1,315 after school snacks ADP and 578.5 with 5,461 after school snacks ADP (Table XI). For Writing, it ranged from an SAT score of 365 with 1315 after school snacks ADP to 574 with 5,461 after school snacks ADP (Table XII).

On average, the accuracy of each of the linear regression graphs showed a mean squared error of 3,500. The mean squared error is a measure of how well a model's predictions match the actual data. The larger the value, the less accurate the output. The neural network had a mean squared error on average of 2,000.

Although the neural network model showed a lower MSE than the linear regression model, the accuracy of the linear regression graphs is generally more reliable than the neural network model graphs, for example (table XIII), because they are simple and lack experimental data outside of my dataset. For this reason, the linear regression model is better suited for this study compared to the neural network model.

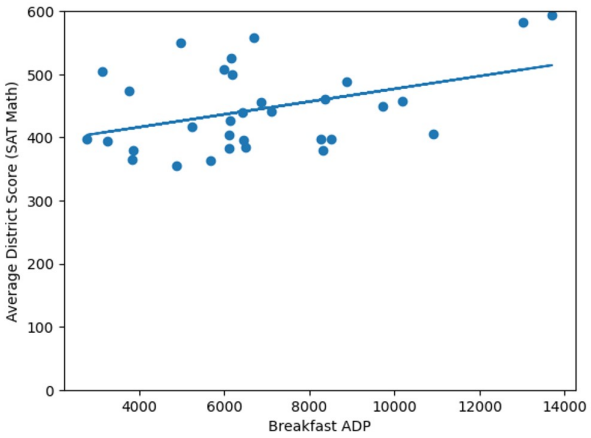

Table I: Math Average SAT Scores and Breakfast Average Daily Participation (ADP)

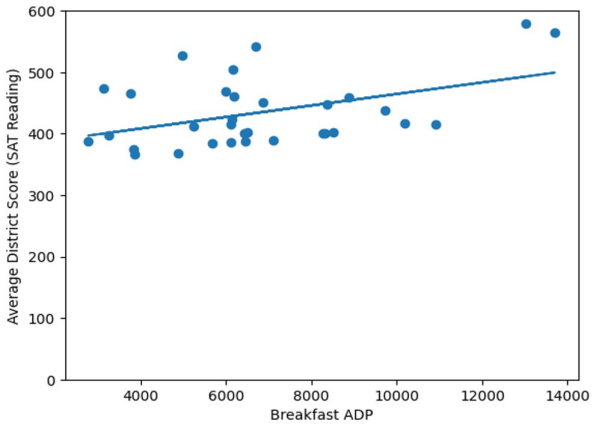

Table II: Reading Average SAT Scores and Breakfast Average Daily Participation (ADP)

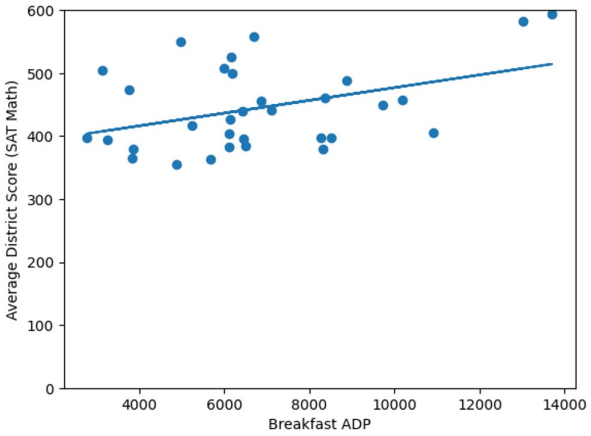

Table III: Writing Average SAT Scores and Breakfast Average Daily Participation (ADP)

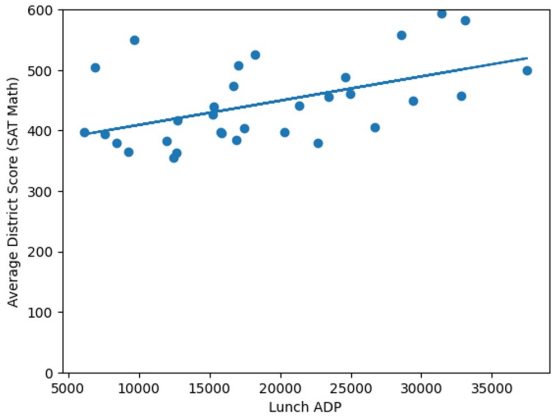

Table IV: Math Average SAT Scores and Lunch Average Daily Participation (ADP)

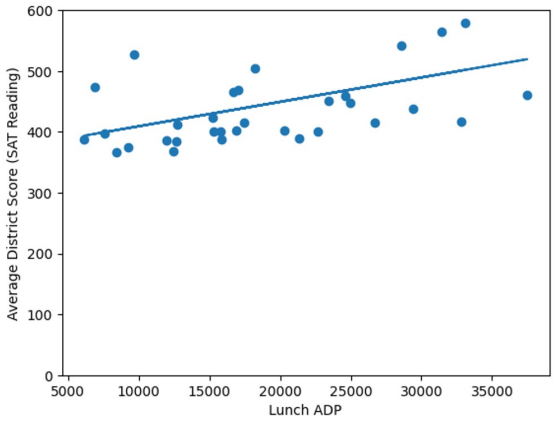

Table V: Reading Average SAT Scores and Lunch Average Daily Participation (ADP)

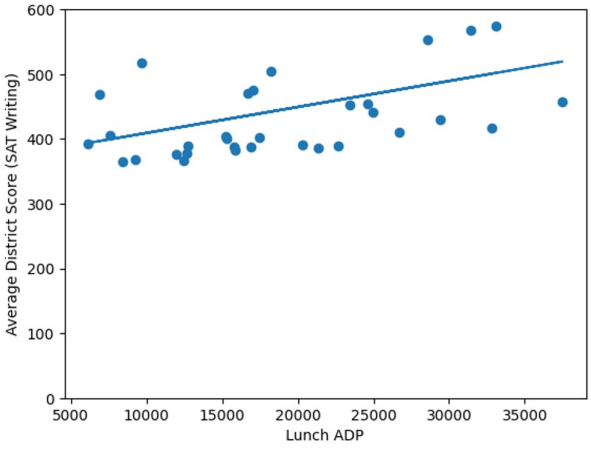

Table VI: Writing Average SAT Scores and Lunch Average Daily Participation (ADP)

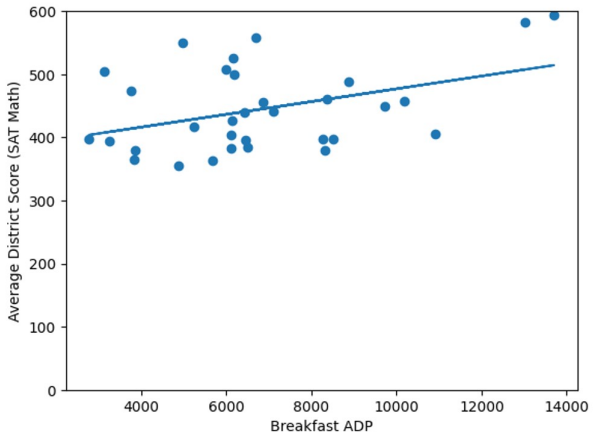

Table VII: Math Average SAT Scores And Supper Average Daily Participation (ADP)

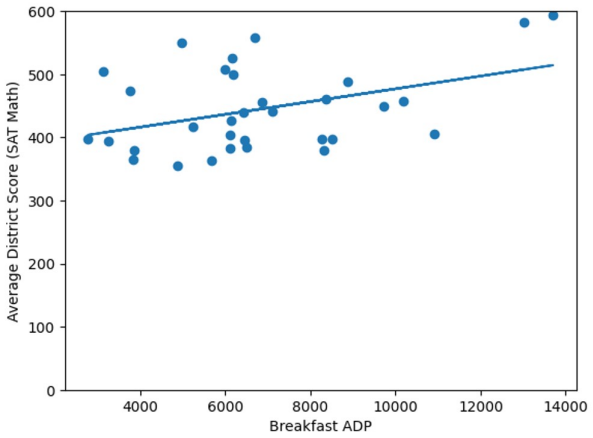

Table X: Math Average SAT Scores and After School Snacks Average Daily Participation (ADP)

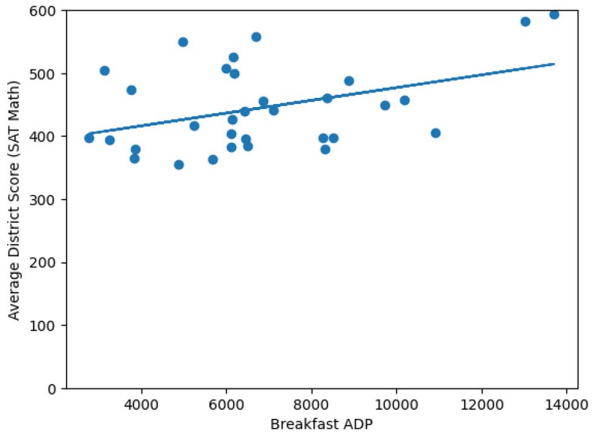

Table VIII: Reading Average SAT Scores And Supper Average Daily Participation (ADP)

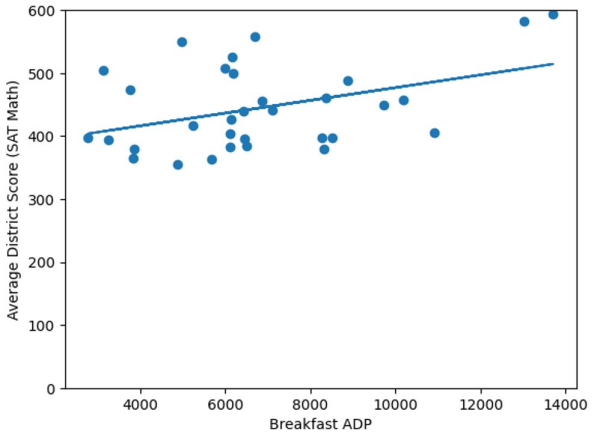

Table XI: Reading Average SAT Scores and After School Snacks Average Daily Participation (ADP)

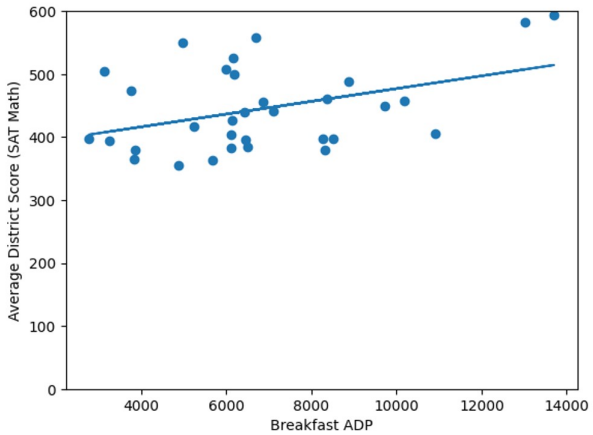

Table IX: Writing Average SAT Scores And Supper Average Daily Participation (ADP)

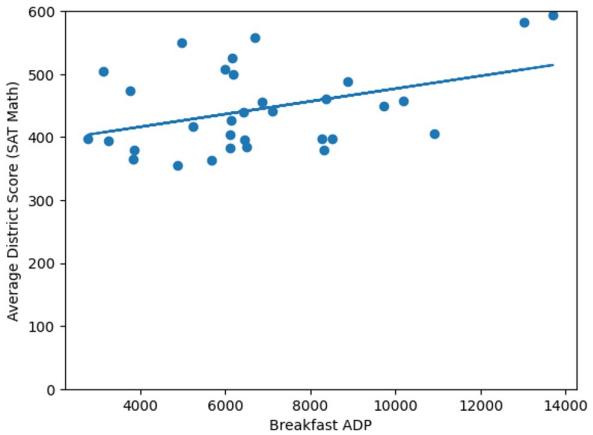

Table XII: Writing Average SAT Scores And After School Snacks Average Daily Participation (ADP)

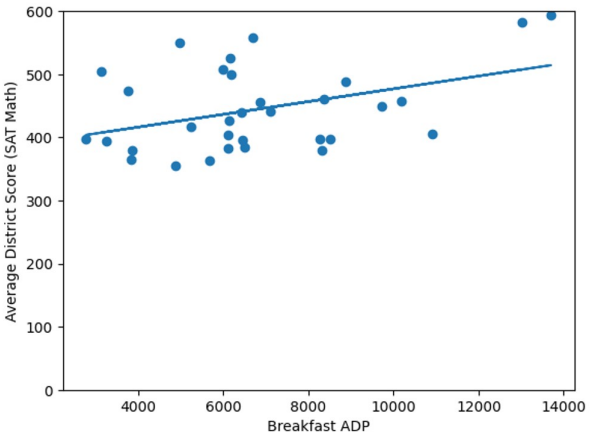

Table XIII: Neural Network Chart Example: Math Average SAT Scores and School Breakfast Average Daily Participation (ADP)

Discussion

The data collected shows higher SAT scores across all sections of the SAT were achieved when correlated with schools that served more breakfast and lunch relative to supper and after-school snacks. The slope of the graph for supper and after-school snacks was smaller than the others, which indicates a weaker correlation. This data may indicate that eating breakfast and lunch is more vital for improving SAT scores for high school students. It is also important to note that more high school students eat more breakfast and lunch at school than supper and after-school snacks, which could be a possible explanation for the weaker correlation.

The neural network model's lower MSE could indicate greater accuracy. However, the neural network model can be subject to overfitting and underfitting and create biases and actually be less accurate because it does not have a diverse enough dataset since it is only relying on data from New York. The linear regression model has more interoperability which could make it have more uses and applications compared to the other models.

Limitations in my models included difficulty accessing specific school meal data and SAT score data for individual students due to privacy laws. While I collected data from New York schools, it would be ideal to collect similar data from other schools across different states. This could introduce a bias in the models that make them most accurate in New York and not in other states. If the model contained data from other places in the U.S., it would likely have broader applicability across other states.

Schools could consider ways to improve or increase access to food for their students as one way to possibly help them perform well on the SAT. However, there may still be a challenge for students, particularly those who are food insecure, which presents an opportunity for future research and exploration. Since school meal programs are not available on weekends, and since the SAT is usually only administered on Saturdays, students who are food insecure may be at a disadvantage relative to students who are not food insecure if they are unable to access school meals like breakfast prior to taking the SAT on Saturday mornings. Does this widen the gap for food-insecure students to be able to perform well on the SAT? While schools may be unable to make food accessible to students on Saturdays when the SAT is often administered, they should at least consider increasing access to food during the school weekdays, as evidenced by the higher SAT scores in this study.

This study did not investigate the nutritional value of food served by the schools at breakfast, lunch, supper, and after-school snacks. Further research could be conducted to discover a correlation between different nutritional values of food and SAT scores.

Conclusion

This study shows that higher participation in school meal programs yields higher SAT test scores for high school students in New York, demonstrating that food could affect aptitude test performance. On average, high school students performed better in all sections of the SAT when more food was being served for breakfast and lunch. This trend did appear the same on supper and after school snacks, however it showed a weaker correlation. Future research could introduce additional factors that likely impact SAT performance, such as socioeconomic status, utilization of tutors, and other factors.

Acknowledgment

Thank you for the guidance of Ihita Mandal, mentor from Carnegie Mellon University in the development of this research paper.

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Appendix

GitHub repository: https://github.com/Jaden-McCarney/Models

The three files located in the GitHub repository are the code for the two linear and neural network models as well as the scores table, which contains the average meal ADP and average SAT section scores for each district in New York.