Impacts of Food Access on K-8 Education Analyzed through Proximity in Sacramento

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ABSTRACT

Food insecurity is an obstacle faced by all levels of society, however, children and their households are at higher risk for food insecurity. The impacts of food insecurity and poor diet quality are long-term for children, as it predisposes them to weaker school performance, social skills, and cognition. Students of color in urban areas, such as Sacramento, CA, are at a more severe low food access disadvantage due to socio-historical trends that caused food establishments to leave the neighborhoods they reside in. I conducted a literature review, mapping assessment, and a statistical test to understand if elementary schools' proximity to nutritious food resources reflects trends in academic performances among their students in the Sacramento City Unified School District. I found that factors such as household income, personal vehicle access, universal school meal programs, and parental/guardian eating habits all influence a student's diet quality and food security status and thus academic performance. I also found that, in the city of Sacramento, there are more K-5 schools located within walking distance and public transportation access than in food deserts. On average, schools located within food deserts have lower percentages of students meeting the ELA and Math standards than schools not located within food deserts. However, location within or not within a food desert is not a strong predictor of academic performance. The findings of this study may be beneficial in city planning and academic policy spheres, as well as for federal funding allocation for elementary schools in urban areas.

KEYWORDS

Food Insecurity, Food Desert, K-5 Education, Diet Quality, Academic Outcomes

INTRODUCTION

The Food and Agriculture Organization defines food insecurity as "not having adequate physical, social or economic access to food for an active and healthy life" (Chilton et al., 2007). According to the U.S. Department of Agriculture Economic Research Service, 10.2% of households in the United States were food insecure in 2021. Trends of food insecurity within households have decreased over time, as census data showed that 14.5% of households were food insecure in 2010 (USDA 2021). However, these broad trends do not depict demographic differences in food insecurity for different types of households. According to the USDA, 12.5% of households with children are food insecure, compared to 9.4% of households without children being food insecure. The impacts of food insecurity on any person are dangerous, however, these risks are amplified amongst children. Specifically, a child's cognitive abilities, and therefore their ability to learn and succeed in school are negatively impacted by non-nutritious diets that can result from food insecurity.

Improper diets are connected to poorer school performance in children. Lack of sufficient nutrients and food insecurity have lasting impacts on children as they develop, with the impacts being more profound the younger the children are. A child whose nutritional needs are not met from in-utero to three years old is more likely to have cognitive deficits, poor school achievement, and higher rates of school dropout when they get older. They are also more likely to have poor social relationships and attention (Chilton et al., 2007). The impacts of food insecurity on cognitive ability are not just felt in early childhood, but in later years of development as well. Healthier dietary patterns are associated with greater attention capacity in adolescents (Henricksson et al. 2017). A healthier diet has consistently positive associations with executive functioning, and children experience improved executive functioning with lower Glycaemic index/load foods (Cohen et al. 2016). A student's academic performance is impacted by their diet at all points in their development. There are a multitude of factors that can influence a student's access to a high-quality diet, including proximity to sources of healthy and affordable food, or more specifically, a student's location within a food desert.

Though the bounds of the term "food desert" have been constantly changing, the United States Department of Agriculture defines these regions as "urban neighborhoods and rural towns without ready access to fresh, healthy, and affordable food" (Wright et al., 2016). These "food

deserts" create food insecurity issues for the residents living within them, although not exclusively. Food deserts epitomize the influence of proximity on food access and diet quality. Low-income students who attend school within these food deserts may have less proximity to healthy, nutritionally sufficient food by attending school in the district in which their household is located. Living and attending school within a food desert that does not provide ample quality and quantity of food for a healthy diet creates obstacles and disadvantages for the academic success of students in these areas (Engler-Stringer et al. 2014), which have lasting physical and economic consequences for these students. A better understanding of patterns of school geographical access to food resources and academic outcomes is necessary for creating more just and supportive food and education systems and can have impacts on a variety of fields, from city planning and infrastructure to education policy and federal funding allocation.

In this study, I ask how does an elementary school's proximity to nutritious food resources reflect trends in academic performances among its students in the Sacramento City Unified School District? I first ask how other factors, such as individual household income and access to a personal family vehicle, influence students' classroom performances. I then consider if there is variation in physical proximity to food resources amongst individual elementary schools. Lastly, I consider if patterns in variation of proximity may predict patterns in academic achievement via standardized test score averages for these elementary schools. I posit that both school proximity, as well as other, more individual, household-based influences, can lead to a lack of access to healthy and affordable food, and therefore lead to lower academic performance within the schools. The objective of my data collection will be to construct a geographical correlation between how far a student's school is from a healthy and affordable food source to how well they performed on standardized tests. I will also construct a literature review that allows me to conclude individual household-based influences on student diet.

LITERATURE REVIEW

Factors influencing student diet quality

Students who are food insecure in kindergarten are predicted to have poorer math performance by the time they are in third grade, poor reading development, and decreased social skills (Jyoti et al. 2005). Food insecurity harms a child's health status, and through that poor health status, their academic performance can be directly and indirectly negatively affected, though it is not exclusively (Ashiabi 2007). Food insecurity can be a consequence of a student's household's lack of proximity to nutritious and affordable food resources, though other socioeconomic factors can also influence a student's access to food.

This lower access to nutritious food has been correlated to worse academic performance (Hickson et al. 2013). A study done in the state of New York found that school districts with higher proportions of individuals living in food deserts had lower 4th-grade achievement in Science, English, and Math, after accounting for additional predictors of academic performance (Frndak 2014). The quality of food sources near schools, specifically variations in quality due to socioeconomic factors, can impact the academic success and physical health of students in both the long and short term. Nearly all public secondary schools in St. Paul and Minneapolis, Minnesota have at least one convenience store within one-half mile. Despite many stores carrying healthier beverage alternatives, the stores lack a wide array of healthy snack options in convenient single-serving packaging. Also, in terms of marketing and placement near cash register areas, unhealthy snacks, and beverage options are most prevalent. Overall, unhealthy snacks are more widely advertised, have a better placement in stores near schools, and are provided in a consistent and extensive selection in virtually all stores (Gebauer and Laska 2011). Not all elementary schools, however, have equal access to healthy or unhealthy food options. In Saskatoon, Canada, elementary schools in low-income neighborhoods are twice as likely to be located within walking distance of a fast-food restaurant or a convenience store compared to schools in high-income neighborhoods (Engler-Stringer et al. 2014). Food resource proximity, often conceptualized through the framework of food deserts, is vital to understanding a student's dietary background.

Food deserts

The term “food desert” is believed to have first been coined in the UK in the early 1990s, and its first official usage in publication was in 1995 (Cummins 2002). The process of food desertification is deeply entrenched in the socio-historical process of white flight, as food retailers and grocery stores followed wealthy white families out of urban areas and into suburbs. This process left low-income families of color and urban areas in general with limited food options, such as fast food chains or liquor stores. The most easily accessible and healthy food is located in the suburbs (Wright et al., 2016). Student household socioeconomic identification, such as race and income status are key indicators in whether that student will have access to a healthy diet via their location within food deserts.

A student’s school’s proximity to nutritious and affordable food resources can be a predictor of their academic achievement in school. Mapping supermarket locations and the English Language and Math performances of Black students in Oakland California revealed a correlation between a school's lower average English language and math proficiency and increased distance to a supermarket in Oakland compared to other schools (Schrider 2021). By studying potential correlations between individual student diets and the food resources around their school, the potential impacts of this geographical proximity and student performance can be revealed.

A school’s physical distance to affordable and healthy food, however, may not paint a complete picture to explain why a student may perform well academically. Barriers to access that stem from social, cultural, and economic factors can lead to a house being food insecure. Even if a household is close to affordable and healthy food, it does not indicate that the household’s nutritional needs are being met. A study done in the United Kingdom found that food prices in low-income regions historically defined as food deserts are on average not higher than in regions where the average income is higher. This study posited that access to a car and food preparation time limitations are significant factors attributing to gaps in nutritional fulfillment in households (Cummins & Macintyre 2002), calling into question the validity of food deserts as an accurate indicator of decreased food access.

Household personal vehicle access

One variable that may influence a child's diet quality is if their guardian or food provider has access to a personal vehicle, such as a car, as these vehicles can be used to transport large amounts of time-temperature sensitive foods quickly and expand the available food options to include healthier options in a household. A study on households in public housing communities in Baltimore, Maryland found a significant association between personal vehicle access and a lower risk of food insecurity, but no associations with improved diet or increased exercise (Martinez et al. 2019). A household's access to a personal vehicle is associated with reductions in food purchases made at restaurants or through delivery, which, on average, have lower dietary quality and higher caloric intake. Personal vehicle access for obtaining food can improve the time and money budgets for food amongst low-income families, reducing their risk of food insecurity (Fitzpatrick and Ver Ploeg 2010).

Researchers in San Diego found that although the distance between households and food sources was consistent amongst varying modes of transportation, it took residents who used public transportation to access these food institutions three times longer to get to these institutions than residents with cars (Swayne and Lowery 2021). Researchers in Boston found that residents that did not have access to household/personal vehicles to access food resources were deterred from taking public transportation due to inconsistent bus and train schedules as well as having to lift numerous heavy grocery bags for extended periods (Scammell et al. 2015).

If the person who provides food for a child does not have access to a personal vehicle, they are less likely to access grocery stores frequently or deliver large amounts of temperature-sensitive healthy food, such as frozen food, dairy products, or meat to the household if they live in a food desert or area that lacks grocery stores nearby. This is due to the excess time and physical effort required to access food resources via walking or taking public transportation requires compared to accessing these same resources with a personal or household vehicle. This inconsistency in diet, such as only having access to processed foods that are shelf stable, having to purchase food from a restaurant, spending extra money for food delivery, or having low caloric intake due to infrequent grocery shopping, can influence how a child performs academically, as poor diet quality and malnutrition have been linked to poor cognitive development, poor attention span, and lower academic outcomes.

Household income

Another variable that may influence a child's diet quality is the income of the household they live in. Even if a child lives or attends school in an area with ready access to nutritious food resources, if their household does not have the budget to buy the food, their diet quality and food security status is at risk. Across the United States, intakes of several nutrients and food groups and overall dietary quality are lower among young children in low-income households compared to mid to high-income households. Overall, if a child comes from a household that reports a low-income status, they are at greater risk of having a lower diet quality (Fadeyev et al. 2021). Higher-income households have significantly higher health eating index total scores, higher total vegetable scores, higher dairy scores, and a lower proportion of grocery dollars spent on frozen desserts than lower-income households (French et al. 2019).

Amongst African-American Households in Baltimore, Maryland, food-insecure households that are experiencing hunger are less likely to have members with full-time or part-time employment. Compared to food-insecure households not experiencing hunger or food-secure households, households that are food-insecure and experiencing hunger are more likely to have household incomes of less than $20,000. Residents of food-insecure households that are both experiencing and not experiencing hunger are more likely to perceive healthy food as inaccessible and expensive compared to residents in food-secure households (Vedovato et al. 2015). These households are also more likely to contain caregivers and children that are overweight. Income is a significant indicator of household diet quality, which impacts the diets of the children in these households. Lower-income households will likely not have enough food to supply a calorically adequate diet to the children living in the household or will have food that is not nutritionally conducive to positive health outcomes amongst its children. These health impacts can negatively affect the academic success of these children.

Parental dietary behavior

Another variable that may influence a child's diet quality is their eating habits. Even if a child has access to healthy foods, when and how often they eat may impede the quality of their

dietary intake, and thus their success in school. One factor that can contribute to a child's eating habits is the eating habits of the people around them as they are developing. The family environment surrounding a child's domestic life plays an active role in establishing and promoting behaviors that will continue throughout their life. Family meals represent an important moment of both control and interaction, which contributes the most to modeling children's dietary habits (Mahmood et al. 2019). If the guardians and people around a child eat at inconsistent times or eat non-nutritious foods in improper amounts, a child will likely mimic these behaviors. The food decisions a parent or guardian makes for themselves are reflected in the food decisions children make for themselves. School-age children who observe their parent or guardian consume fruit juice and vegetables are more likely to have a higher intake of fruit juice and vegetables themselves (Savage et al. 2007).

Beyond the dietary habits of students' parents and guardians, the awareness of the importance of proper nutrition and calorie intake amongst parents and guardians influences the diet quality of students. Parents with a higher awareness of healthy nutrition and calorie intake have children that consume more vegetables and less frequently consume candies and soft drinks (Nazzaro et al. 2018). Family and parent/guardian eating patterns are influential on a child's dietary habits long-term. The frequency of meals and snacking, the portion sizes, and the food choices that a parent or guardian makes are reflected in those same decisions that a child makes for themselves in both childhoods as well as into their adult lives. If a child is functionally consuming an improper diet due to the eating behaviors modeled for them in their households, their academic performance can be negatively affected. Malnutrition intake due to incorrect food choices, obesity due to incorrect meal portion sizes, or inadequate calorie intake for sufficient energy can all affect if a student is prepared to learn and succeed in a classroom setting.

School meal programs

Another variable that can influence a child's diet quality is whether they have access to meals at school. Even if a child's household is food insecure, access to food at school can determine if their diet quality is nutritionally and calorically sufficient. Food insecure and marginally food-secure students had a higher energy intake from school meal foods, whether that be from a School Breakfast Program or National School Lunch Program, than food-secure

students. All three food status groups experienced a higher dietary quality from school-provided food than from non-school-provided food (Forrestal et al. 2021). Universal free school meals benefit all students, but especially those who are food-insecure and near eligible for free meals in existing school meal models. Universal free school meals are associated with increases in participation, improved diet quality, and increased rates of food security, as well as either no change or improved BMI. Not only does universal school meal access improve student health, but academic performance (Cohen et al. 2019).

Expanding access to universal free meals benefits at-risk children especially, leading to gains in reading scores and reduced risk of obesity among students from low-income households (Andreyeva et al. 2021). The caloric and nutritional adequacy in diets amongst students who consume food provided by their school is improved, and thus their health outcomes are better, which can lead to improved academic performance. Although improvement is most significant amongst food-insecure students, all students' health outcomes improve with the expansion of school meal programs. Universal meal programs in which all students have access to school meals regardless of household income have been correlated to improved academic performance for elementary-age children as well as positive health impacts.

METHODS

Study site

The city of Sacramento sits on 97.92 square miles of land and has a population of 525,041. With 5,323.4 people per square mile, the city qualifies as an urban region. 30.78% of households in Sacramento have children (United States Census Bureau). The Sacramento City Unified School District (SCUSD) encompasses 86 schools, 53 of which are elementary schools, and enrolled 46,657 students in the 2019-2020 school year. SCUSD is the eleventh largest and one of the most ethnically and linguistically diverse school districts in California, with 39% Latinx students, 20% Asian and Pacific Islander students, and 14% African American students as well as more than 48 languages spoken by students and families in the district. 70% of students in the school district are considered socioeconomically disadvantaged (Hahnel and Melnicoe 2019). Of the students enrolled in the SCUSD, 51% of students are eligible to participate in the

federal free and reduced-price meal program (U.S. News). In the greater city of Sacramento, 42% of children in low-income households are food insecure (De La Torre 2021). The population of Sacramento is, on average, more food insecure than the national average, with 25% of households enrolled in food assistance programs compared to the national average of 10.5% (Salanga 2021).

One of the largest factors contributing to food insecurity in low-income households in Sacramento household is geographic access to supermarkets and food banks. One-third of respondents to a poll done in 2021 to understand the barriers low-income individuals face in accessing food banks reported that they had to drive over 15 minutes to access food banks. On top of this, if an individual or household does not have a car, they have to take into account the extra time and limited carrying capacity of using public transportation to access food banks and supermarkets (Salanga 2021). The results of this poll are on trend with the results of the process of food desertification. The regions of Sacramento in which grocery stores are more evenly spread are predominantly white neighborhoods, while neighborhoods in which grocery stores are absent or not as evenly spread are minority-majority neighborhoods (Phan and Wolf 2020). Food deserts and socioeconomic factors are not independent influences on Sacramento households' food security statuses, as they interact and create each other. Another factor contributing to food insecurity amongst low-income households in Sacramento is barriers to access to food assistance programs, such as language barriers or undocumented status preventing someone from being able and comfortable in filling out an application for food assistance, even if they qualify (Salanga 2021).

Analyzing factors influencing elementary-age student diet quality

Data collection

For my literature review analyzing confounding variables on student diet quality outside of school geographical proximity to food resources, I found documents using the UC Berkeley online library database as well as the google scholar search engine. In the UC Berkeley online library search engine, I utilized key phrases including "food insecurity", "nutrition intake", "caloric intake", and "academic performance" in conjunction with phrases including "personal

vehicle access", "household vehicle access", "parent eating behavior", "parental dietary pattern", "universal school meal programs", "free school lunch program", "household income". I included documents that are systematic reviews of previous research done. I also analyzed studies that researched the importance of diet on cognition and academic success to frame the importance of food access on elementary school academic outcomes.

Data analysis

I prioritized sources and information published in peer-reviewed journals and used data collection and analysis methods that take into account the demographic information of the populations they are surveying in their results. I mainly collected studies conducted after 2014. I collected studies that mainly focused on individual cities in the United States, or U.S.-based, nationwide studies, as food-security influencing factors such as food assistance programs and civil design are unique from country to country. I collected at least three studies to support the relevance of each factor influencing student food security and diet quality. In total, I collected 23 studies to use in my literature review. I extracted the key findings from these studies to use in support of how confounding variables including, household vehicle access, parental or household eating habits, universal school lunch programs, and household income impact a student's diet quality and personal health, and therefore their academic performance.

Analyzing variations in elementary school proximity to food resources

Data collection

I used the Sacramento Food Desert Map created for The View From Here: Hidden Hunger Project to understand the distribution of food deserts in Sacramento in 2014. This project collected food resource data for the map from the Sacramento Food Atlas at Sacramento State University and the Sacramento Food Bank and Family Services. This food desert map included food resources such as supermarkets, farmer's markets, ethnic food markets, and food banks to understand the distribution of food resources in Sacramento. I collected data for the Elementary Schools I studied from the California Assessment of Student Performance and Progress online

database (CAASPP). I collected standardized test data from the 2018-2019 school year, school addresses, school geographical coordinates, school names, and school code data for elementary schools in the Sacramento City Unified School District. I analyzed testing data from the 2018-2019 school year as it was the most recent year that was unaffected by the COVID-19 pandemic, as I did not research the impacts the pandemic had on student diet quality. Of the 53 elementary schools in Sacramento, I collected CAASPP data for 42 of the schools, as these 42 schools were kindergarten through 5th-grade educational institutions.

Data analysis

I imported the map data from the Hidden Hunger Project into ArcGIS to overlay the school data I collected onto the map. The map identifies food desert regions, regions in which food resources are accessible via public transportation, and regions within walking distance of a food resource. I transferred the school data, which included the percentage of students meeting the standard for English Language Arts and Math as reported by the CAASPP database, the school address, name, code, and geographic coordinates into an Excel spreadsheet. I used the coordinate data to plot each school's location on the food desert map as well as input the academic performance data into the map. I then input which schools were located in food deserts, in areas with public transportation access to food resources, or within walking distance of food resources into the Excel spreadsheet I created and tallied the number of schools found in each of these regions.

Comparing academic performances and elementary school proximity to food resources

Data collection

In the Excel spreadsheet that I created to understand variations in elementary school proximity to food resources, I categorized each school's proximity to food resources by a number, so schools that were located within walking distance of schools were attributed the number 1, schools with public transportation access were attributed number 2, and schools within food deserts were attributed number 3. I attributed a n/a to schools outside of the bounds

of the food desert map. I then removed the schools that did not have any food resource proximity data, leaving me with 31 schools. I then converted my Excel spreadsheet into a CSV file and imported this file into R Studio for data analysis.

Data analysis

In R studio, I first calculated the average % of students meeting the standard for English Language Arts and Math respectively for each food resources proximity region, and then input this data into Excel to create and then graph this data to better visualize any variations. I then ran the school proximity to food resource data and the % of students meeting the standard for English Language Arts and Math data in a linear regression model to understand if the two variables are associated. I then input the p-values I retrieved from the linear regression model into the Excel spreadsheet.

RESULTS

The purpose of my study was to determine if, in Sacramento, there are variations in the amounts of elementary schools located in, or not located in, food deserts as well as if a school's location in a food desert is an indicator of academic performance for the students in those schools. I found that a majority of schools in my study sample were not located in food deserts. Of the 42 schools in my sample, 13 were located within walking distance of a food resource, 13 were in a location with public transportation access to food resources, 5 were located in food deserts, and 11 were not located within the bounds of the Food Desert map I used.

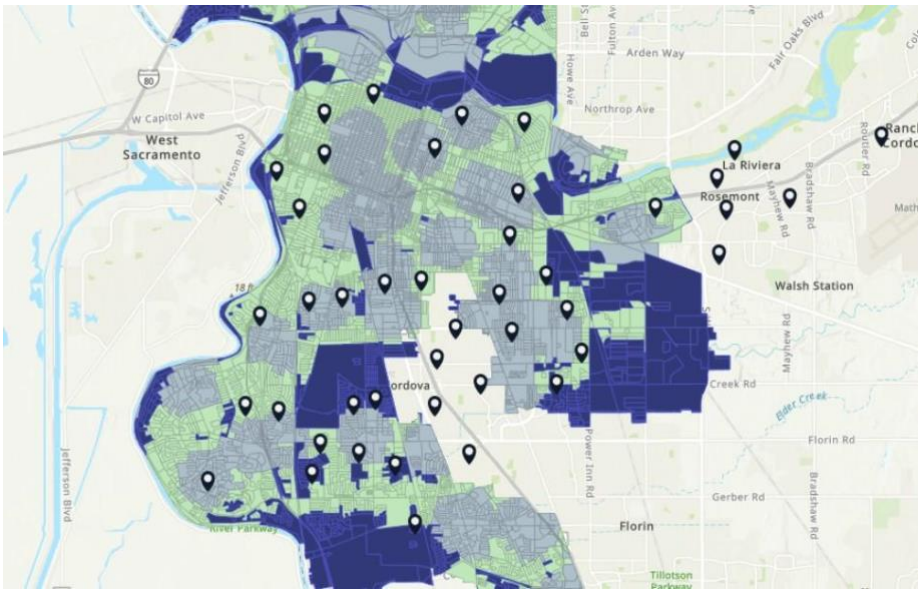

Figure 1. Food Desert Map of Sacramento with the 42 K-5 schools in the Sacramento City Unified School District. The gray areas on the map represent regions within walking distance of a food resource, the green areas represent regions with public transportation access to food resources, and the blue areas represent food desert regions.

In terms of percentages of students meeting the standard for English Language Arts and Math, schools located in food deserts had the lowest percentage of students meeting the standard in both subject areas, with an average of 29.9% of students meeting the standard for ELA and 30.94% meeting the standard for Math. Schools within walking distance of food resources had the highest percentage of students meeting the standard for both subjects, with an average of 41.25% of students meeting the standard for ELA and 37.87% of students meeting the standard for Math. In schools located with public transportation access to food resources, 39.74% of students met the standard for ELA and 33.42% of students met the standard for Math.

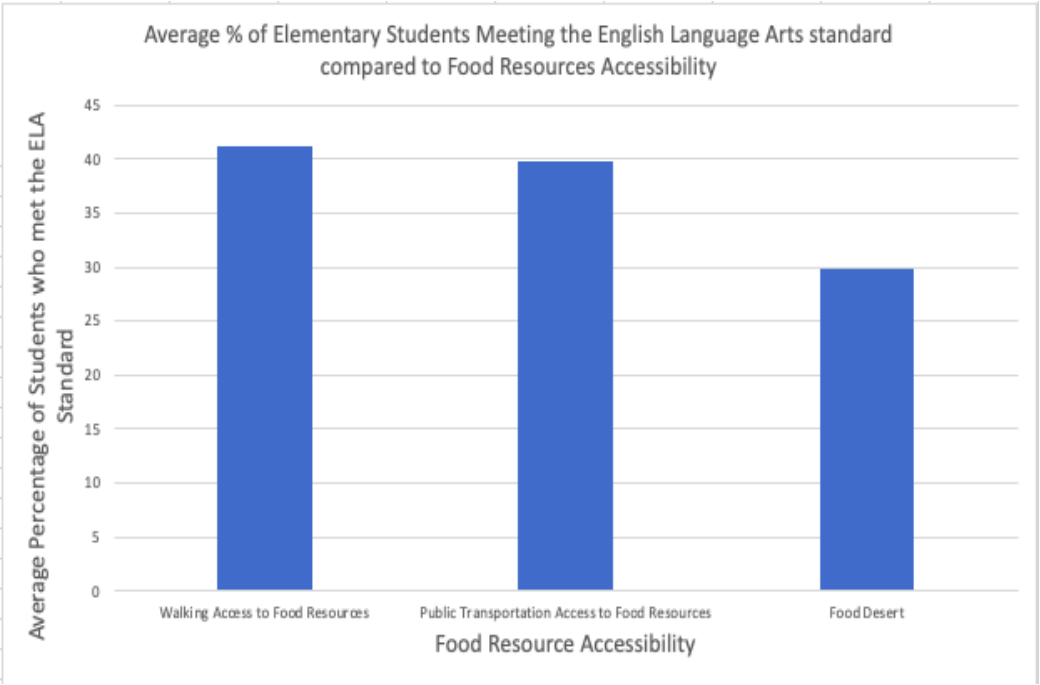

Figure 2. Bar graph depicting the average percentage of students meeting English Language Arts standards by school accessibility to food resources identifiers. School within walking distance to food resources had the highest percentage of students meeting the ELA standard and schools in food deserts had the lowest percentage.

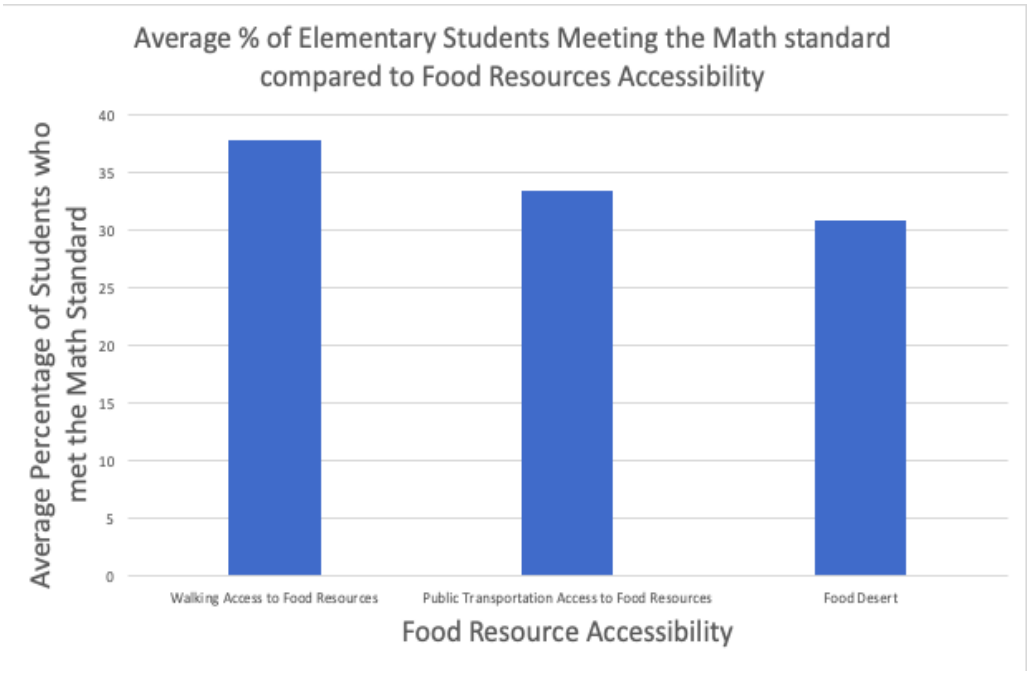

Figure 3. Bar graph depicting the average percentage of students meeting Math standards by school accessibility to food resources identifiers. School within walking distance to food resources had the highest percentage of students meeting the Math standard and schools in food deserts had the lowest percentage.

To better understand if school proximity to food resources influenced elementary-age students' academic performance, I ran a linear regression model with the CAASPP data against school location identifiers for both subjects. I found that for both ELA and Math, a school's geographical proximity to a food resource was not a predictor of the percentage of students meeting the standard. The p-values for the linear regression models I ran using the percentages of students meeting the standard for Math and English Language Arts were 0.51 and 0.43 respectively. These p-values indicate that variations in percentages of students meeting subject standards between schools with varying geographical accessibility to food resources cannot be attributed to that geographical accessibility variation.

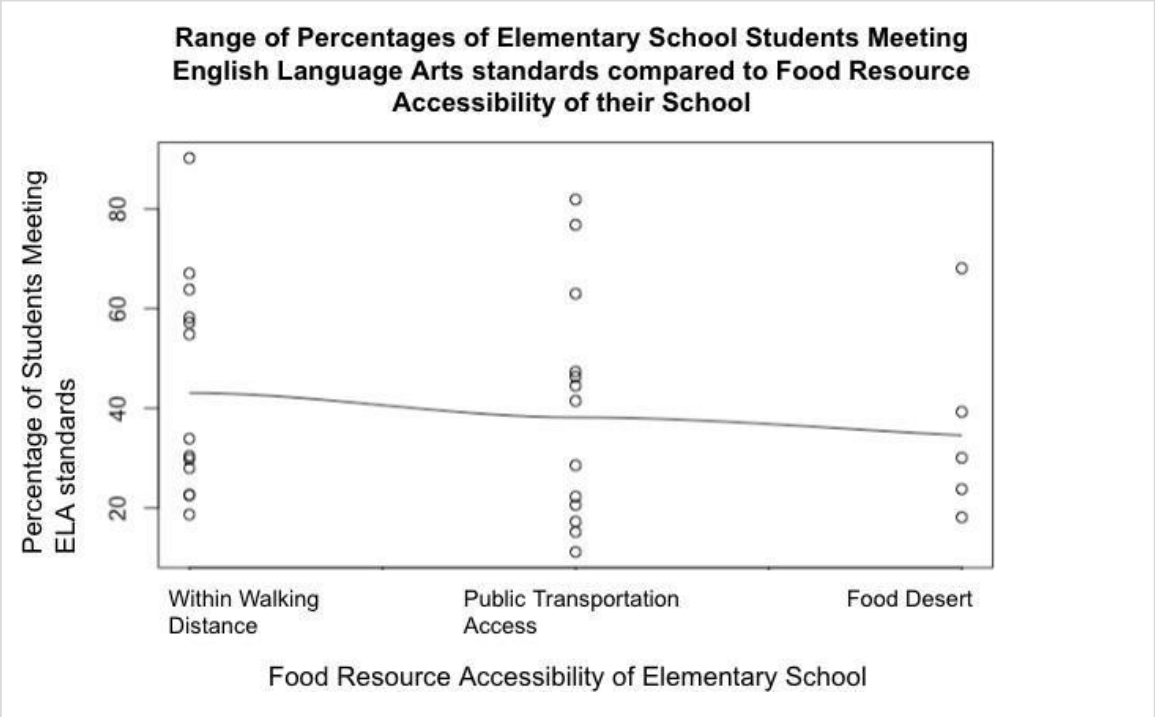

Figure 4. Distribution of percentages of students meeting English Language Arts standards for each school in each accessibility category.

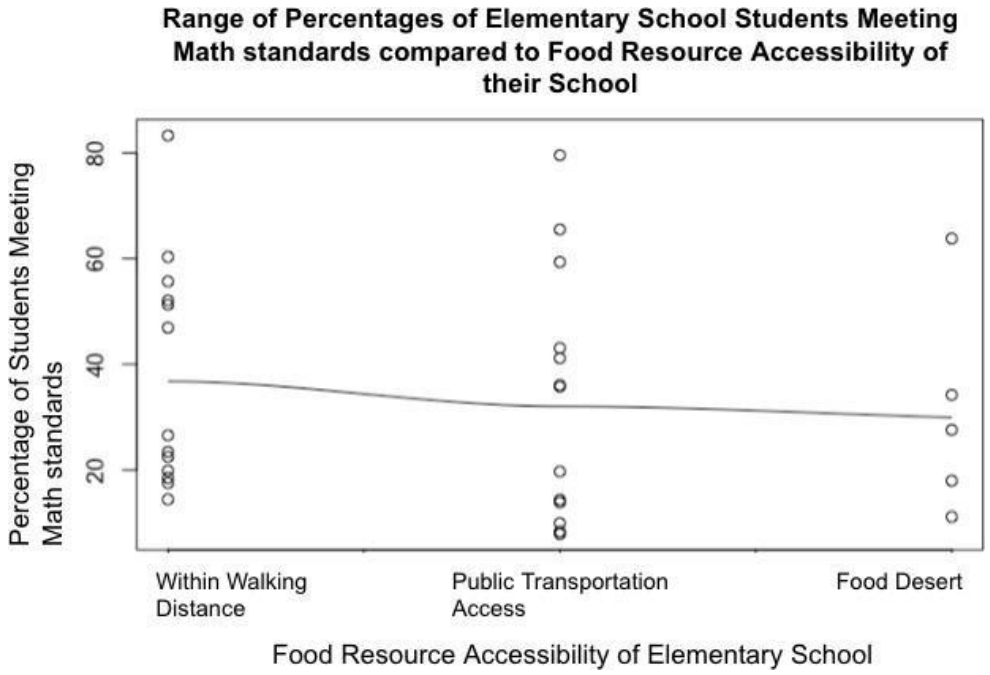

Figure 5. Distribution of percentages of students meeting Math standards for each school in each accessibility category.

DISCUSSION

I found in Sacramento, CA, of the 31 elementary schools in my test group, more schools are located in areas within walking or public transportation access to food resources, while the number of schools in food deserts was less than half of the number of schools within both walking distance and public transportation accessibility individually. This conclusion is in alignment with the historical context of the process of food desertification in neighborhoods due to socioeconomic processes. On average, schools within food deserts had the lowest percentage of students meeting the testing standard for both English Language Arts and Math, and schools within walking distance of food resources had the highest percentages, with schools within public transportation accessibility falling between the two. School location corresponding to food resources, however, cannot be used as a predictor of academic achievement within those schools, as a linear regression analysis of the standards met data set and the school food resource proximity data set does not show a strong correlation between the two variables. These results

align with the findings of S. Cummins and S. Macintyre 2002. These results also emphasize the importance of addressing other factors that affect school performance through food security analyzed in the literature review section.

Number of schools in food deserts in Sacramento

The number of schools located in food deserts was 5, while there were 13 schools located in areas within walking distance of food resources and 13 schools in areas with public transportation access to food resources. This disproportion is reflective of the process of food desertification in the United States, in which food operations such as supermarkets follow wherever white people migrate to in terms of urban and suburban areas, and away from predominantly black and brown neighborhoods. This happened because, on average, white people made and still make larger incomes and food operations prioritize opening and selling food in higher-income neighborhoods (Wright et al. 2016). This income disparity may explain why neighborhoods in food deserts also host fewer schools in Sacramento, as public schools rely on the income tax of the area they are located in. This theory is supported by demographic data on food deserts in Sacramento. A 2020 study found that, in Sacramento, food deserts have a higher probability of existing in minority-majority census tracts, compared to white-majority census tracts (Phan and Wolf 2020). Economic disenfranchisement of minority groups in Sacramento led to a decrease in the number of both schools and food resources in the areas in which they reside. The absence of these two institutions in minority communities is not an independent phenomenon, as the absence of food resources in a community is indicative of the absence of adequate educational institutions in a neighborhood or community. Academic opportunity and success are necessary for future financial success and higher incomes, and neighborhoods that lack these opportunities and academic success will not see as a great future financial success for its inhabitants, which will lead to an increased likelihood of food desertification in that neighborhood. Overall, the disparity in the number of schools in food deserts is indicative of larger socioeconomic trends in Sacramento, which are important to study to understand both food and educational resource allocation issues in the city.

Statistical analysis of the relationship between school location and test score data

On average, in both English Language Arts and Math, schools located in food deserts had the lowest percentage of students meeting the standard. Schools located within walking distance of food resources had the highest percentage of students meeting the standard for ELA and Math, with schools located within public transportation access falling between these two location descriptors. Although there is a correlation between school location and the percentage of students meeting academic standards, linear regression analysis reveals that school proximity to food resources is not a predictor of academic performance in these schools. The results of this study highlight the importance of not solely focusing on location and proximity in terms of food access and academic achievement. A 2002 study done in the United Kingdom also studied the efficacy of food deserts in understanding food access and found that the evidence supporting policy decisions around food deserts in the UK is not strong enough for food deserts to be the most important factor in food policy-making (Cummins and Macintyre 2002). A school's location in or outside of a food desert, according to the present study, should be considered in tandem with other social factors when it comes to elementary school achievement and food access.

Importance of other social variables on student food access and academic achievement

In reviewing previously conducted studies to understand the impacts of other social factors on food access written after 2014, I found that household income, personal/household vehicle access, universal school meal programs, and parental/guardian eating habits are all important indicators of whether a household is food insecure. Thus the children in that household's academic achievement are impacted due to their food insecurity. These factors are important to consider alongside the location of a school in, or not in, a food desert. A 2014 paper studying the impact of a 4th grader's home location in, or not in, a food desert and their academic achievement in New York State, supports the results of the present study. This 2014 paper found that, in English and Math, low food access amongst student households was not a significant predictor of variations in achievement scores for both subjects. However, households with both low food access and low income as well as households with low food access and no

personal vehicle access were significant explainers of variation in test scores for both English and Math (Frndak 2014). Food deserts are important concerning academic achievement when coupled with additional socioeconomic predictors, as one variable will exacerbate the effect of the other variable and vice versa.

This 2014 study, along with the results of the present study, are both evidence of the importance of considering multiple and connected factors when determining to understand student academic performance regarding food access. Physical proximity to food resources, whether that be elementary schools' or households' proximity, should not be the main determinant in policy making or resource allocation surrounding education and food access. Intervention strategies for low food access students should take into account personal vehicle access, household income, parental eating habits, and school lunch programs, especially in neighborhoods and communities that have been entrenched in food deserts historically, as all of these factors influence the academic success of the students attending schools from and within these areas.

Comparing the results of the present study

The results of the present study align with similar studies analyzing food access and education. A 2021 study analyzing African American students' academic success and food deserts in Oakland California found that schools with higher percentages of African American students were more likely to be located within food deserts. This study also found that schools in areas with lower food access had lower rates of proficiency in English Language Arts and Math (Schrider 2021). Similarly to Oakland, neighborhood demographic trends in Sacramento show that minority groups are more likely to live within food deserts. The similarities in socio-historical processes of redlining in both Sacramento and Oakland may explain similarities in results between the two studies. The results of the study done in Oakland align with the results of the present study, as the percentage of students meeting the standards for ELA and Math in elementary schools in Sacramento are lower in schools located in food deserts. Both of these studies also highlight the importance of looking not solely at food deserts to understand academic outcomes, but rather considering social variables in tandem with physical proximity for food access. The study conducted in Oakland analyzed food access and academic outcomes

through the lens of race, which I believe should also be done in studying food access and elementary education in Sacramento. The results of the present study conducted in Sacramento, as well as the study completed in Oakland, support the necessity to understand socio-historical processes influencing food access, as both of these variables work together to influence the academic outcomes of students in urban areas.

Limitations

There were several limitations to this study. Firstly, this study only considered food-related factors when determining to understand impacts on elementary academic achievement. A multi-variable study can shed more light on the relationship between food-related and non-food-related factors on elementary educational success, such as language barriers or extra-curricular student participation. Secondly, this study only considered aggregate data on a whole school level, not individual student data. Interviews with students and/or parents can help create a more detailed understanding of the realities of food access and academic achievement. Thirdly, the data set used in this study was small, and expanding the data set to cover a broader student age range or studying non-urban education and food systems would be beneficial in gaining more nuance in this area of study. Lastly, this study took place in Sacramento using data before the COVID-19 pandemic, thus, the conclusions gathered from this study may not directly apply to other urban centers and do not take into account the effects of the COVID-19 pandemic on elementary students' academic performance or their access to food.

Future directions

The findings of this study would be supportive of further research in the food and academics field. This study would support the relevance of a longitudinal study of students attending schools in food deserts or low-food access areas. The influence of food deserts on academic achievement is notable, as seen in the present study, and the long-term effects on the financial success and quality of life for students attending schools in food deserts compared to students attending schools with greater proximity to food resources may reinforce the significance of the present study. The findings of this study would also support further research

using a wider sample group of schools. Expanding this study using a nationwide school testing data set would allow for more accurate statistical analysis to more fully understand if elementary school proximity to food resources is a predictor of academic achievement. Expanding the sample set of schools would also allow for a deeper understanding of the differences between food insecurity in urban and rural areas, as the solutions to address both types of food insecurity are likely different.

Conclusion

The purpose of this study was to gain a more nuanced understanding of the significance of the proximity of an elementary school location on student success, as much of the previous research done in the food access and the academic sphere has focused on household location. I found that, in Sacramento, there are more schools in locations with access to food resources, either walking or public transportation, and fewer schools in food deserts in which food is not as easily accessible. I found that, on average, a lower percentage of students in schools located in food deserts meet the standard for English Language Arts and Math, compared to students in schools with greater access to food resources. However, proximity variation amongst elementary schools is not a predictor of variations in the percentage of students who meet the standard in ELA and Math between those schools. Other variables should be taken into consideration when analyzing student achievement and student diet quality, including the income of the household they come from, whether the person providing food for the student has access to a personal vehicle, the presence of universal school lunch programs in schools, and the eating habits of the members of a student's household. These factors are important to study independently, as well as in conjunction with a school's proximity to food resources.

There is a wide range of potential implications from the findings of this study. Firstly, my finding that fewer schools are located in food deserts than not in food deserts in Sacramento may point to funding disparities between the neighborhoods experiencing low food access and neighborhoods experiencing high food access. More federal or state funding should be allocated for not only more education institutions in these low-food access neighborhoods but also funding to create more community food resources as well as opportunities for a thriving neighborhood economy. Secondly, my finding that schools in food deserts, on average, have a lower percentage

of students meeting ELA and Math standards, but also that school location is not a predictor of standardized test score disparities, shows the importance of analyzing multiple socioeconomic factors in terms of academic performance and food access. Food deserts, while important to take into consideration along with other factors, should not be considered independently when making urban planning or state funding decisions related to academic institutions.

In terms of urban planning, public transportation systems for households that do not have access to personal vehicles should be considered to create a more equitable and accessible food and academic system. In terms of funding allocation, expanding universal school lunch programs to create school breakfast programs is also pivotal to creating more equitable and accessible food and academic systems. In terms of policy change, broadening the qualifications for Calfresh benefits and simplifying Calfresh application processes also work towards these goals. And in terms of public knowledge, creating programs that educate households on affordable food purchasing options and healthy eating habits also works towards the goals within urban food and education systems. All of these intervention strategies require each other to see significant improvement for students experiencing low food access in their academic and future financial success.

The city of Sacramento is demographically diverse and trends in food systems and education disparities in Sacramento are reflective of trends seen more broadly in urban centers. Though not exactly the same, analyzing food realities facing young students in Sacramento can lead policymakers, state funding institutions, and urban planning and data distribution efforts in other states and urban centers to more informed decisions. Food deserts can play an important role in this analysis, however, food deserts should not be analyzed independently, rather a more holistic review of urban foodscapes and their interaction with sociohistorical processes is vital to fully visualize the nuance and inequities occurring in these urban centers. Diet plays a massive role in the cognitive development of children, with rippling effects on their social and academic development, and even further into their future financial and overall life success. Thus, ensuring all students are given the dietary resources they need to be educated will allow urban planners, policymakers, funding institutions, and education distributors to address other issues facing both urban education and food systems. Food accessibility is an issue felt in all aspects of society, but its influence in academic settings impacts not only contemporary childhood development but has the potential to either perpetuate or resolve future social disparities.

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