**It Shouldn't take a Pandemic to increase School Meal Access for Low-Income Students:
A Two-Step Floating Catchment Area Analysis of School Meal Access during COVID-19**

Jason Jabbari, PhD
Yung Chun, PhD
Pranav Nandan, MPH
Laura McDermott, BS
Tyler Frank, MS
Dan Ferris, MPA
Sarah Moreland-Russell, PhD
Stephen Roll, PhD
Washington University in St. Louis

Author Note

Correspondence concerning this article should be addressed to:
Jason Jabbari, jabbari.jason@wustl.edu; (314) 757-0263

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On March 11th, 2020, the Novel Coronavirus Disease (COVID-19) was declared a global pandemic by the World Health Organization. Two days later, a national emergency was declared in the United States. After this declaration, most K-12 schools closed their physical doors (Auger et al., 2020). While schools were able to offer instruction virtually, these school closures made it more difficult to serve school meals, which can promote health, development, behavior, and achievement (Ruffini, 2018). Moreover, these disruptions in school meal access pose disproportionate risks to students from low-income families. For many of these students, the free- and reduced-price meals they receive from their schools make up the majority of their diet (Van Lancker & Parolin, 2020). The physical closure of schools thus created a barrier to accessing a basic human need for over 30 million students who participate in the national school lunch and breakfast programs (U.S. Department of Agriculture, 2020a).

Many school leaders and policy makers attempted to break down this barrier by providing students with alternatives for accessing free meals during the pandemic (McLoughlin et al., 2020). They did so by introducing and expanding summer meal locations. However, as many students lack adequate transportation and most alternative access plans require meals to be picked up at these locations—rather than dropped off at students' homes (McLoughlin et al., 2020), physical proximity to meal access points is of primary importance for students' health and well-being. Moreover, proximity to these meal access points may be unevenly distributed geographically, which may represent a source of geospatial inequality. Despite these substantial disruptions in meal access due to COVID-19 and the associated risks to students in low-income families, there have been few studies examining this issue.

In the first analysis of its kind, we analyze physical proximity to meal access points before and during COVID-19 in St. Louis, Missouri, which includes both St. Louis City and St. Louis County. After the 2015 death of Michael Brown in Ferguson, Missouri, community leaders coalesced around a grassroots civic engagement and action movement—*For the Sake of All*—with a primary goal of increasing child equity in health and its social determinants (Purnell et al., 2018). COVID-19 provides a test for these efforts and a unique opportunity to see if St. Louis is able to live up to this call for greater health equity for children. St. Louis is also uniquely situated for a geographic exploration of this type, as it is sharply divided across an urban core (St. Louis City) and surrounding suburbs (St. Louis County). As most of the studies that explore geographic opportunity in relation to food access have focused on either urban cores (see Sonnino, 2016) or rural areas (see Walker et al., 2010), food accessibility in suburban areas remains largely unknown. This especially problematic when considering that social services have been unable to keep up with dramatic rises in suburban poverty (Allard & Roth, 2010).

In order to understand meal access, we consider both the “supply” of free meals and the “demand” for them. To do so, we employ a two-step floating catchment area analysis to analyze meal accessibility. This approach accounts for both the number of meal access points within a given geographic region *and* the number of families living below the federal poverty level. We pose the following research questions:

1. *How does meal access during COVID-19 relate to Free and Reduced-Price Lunch status?*
2. *How did school meal accessibility and participation change during COVID-19?*
3. *How do changes in meal accessibility during COVID-19 correspond to measures of race/ethnicity and socioeconomic status?*

Overall, we find that while meal access during the spring semester of 2020 (May 2020) was substantially lower when compared to the previous spring semester (May 2019), meal access during the summer of 2020 was substantially higher when compared to the previous summer. Additionally, increased access was most prevalent in low-income areas and areas with a higher proportion of African Americans.

Background

Child Food Insecurity and School Meals

Prior to COVID-19, approximately 14% of households with children experienced food insecurity (Feeding America, n.d.), which has a negative effect on children's academic performance, weight gain, and social skills (Jyoti et al., 2005). As participation in school meal programs decreases food insecurity and increases nutrition (Food Research & Action Center, n.d.), it is unsurprising that school meals are associated with improved health (Davis & Musaddiq, 2019), behavior (Gordon & Ruffini, 2019), and academic achievement (Ruffini, 2018; Gordanier et al., 2020). School meals are most important for nearly 30 million students who participate in the National School Lunch Program and the nearly 15 million students who participate in the School Breakfast program (Billings, 2020). Administered within states and managed by the U.S. Department of Agriculture, access to these programs is determined by household income. Children with household incomes below 130% of the Federal Poverty Level qualify for free meals, as do those from households receiving Supplemental Nutrition Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF).

Moreover, as many students receiving free and reduced-priced meals during the school year could likely benefit from these offerings during the summer months, summer meals have become an important topic for policy makers and other stakeholders interested in alleviating

child food insecurity. The Summer Meals Program is commonly administered through the Seamless Summer Option and the Summer Food Service Program—where schools, as well as camps, nonprofit organizations, and other government agencies can receive reimbursements for serving meals. Huang et al. (2015) found increased food insecurity in June and July for families that participated in free- and reduced-price lunch programs during the school year. Similarly, Khun (2018) demonstrated that summer meals may help alleviate cyclical food insecurity. Nevertheless, without mandatory attendance, it is difficult for many low-income students to access summer meals—only 14.1% of children who received free or reduced-priced lunches during the 2017-2018 school year received free or reduced-priced lunches during the following summer (Hayes et al., 2019). As spring school closings resemble a typical summer in terms of meal offerings, recent research shows increased food insecurity for families with children during the COVID-19 pandemic (Ahn & Norwood, 2020).

COVID-19 and School Meals

In response to COVID-19 and nationwide school closures, the federal government passed the Families First Coronavirus Response Act (FFCRA) and the Coronavirus Aid, Relief, and Economic Security (CARES) Act. These efforts provided billions in funding for additional food supports through existing programs like SNAP and new programs like the Pandemic Electronic Benefit Transfer program, as well as reforms meant to help increase access to existing nutrition supports. Most relevant to our study, the FFCRA gave the USDA authority to grant waivers in order to help schools and other community organizations provide meals and snacks during COVID-related school closures (Aussenberg & Billings, 2020; Barton, 2020). These waivers are open to all states and allow for increased flexibilities in *where*, *when*, and *how* meals are served during COVID-19 through the Seamless Summer Option (SSO) and the Summer Food Service

Program (SFSP) (U.S. Department of Agriculture, 2020b). These flexibilities include the following:

- An *SSO/SFSP Area Eligibility Waiver* that waives the summer meal program requirement to limit "open site" meal service to areas where a minimum of half of the children in the area are from low-income households;
- A *Meal Time Waiver* that allows for meals to be served outside standard meal times;
- A *Non-congregate Feeding Waiver* that allows meals to be provided outside of typical group settings; and
- A *Nationwide Parent/Guardian Meal Pickup Waiver* allowing parents and/or guardians to pick up meals for their children without the student being present (adopted in 41 states)

St. Louis, Missouri

As we analyze St. Louis's response to student meal access during COVID-19, it is important to understand the nature of poverty and food insecurity that existed in St. Louis and the state of Missouri prior to the pandemic. While estimates from the National Center of Education Statistics (NCES) demonstrate that the percentage of students in Missouri eligible for free or reduced-priced lunches was only slightly higher than the national average (53% compared to 52%), Missouri has one of the lowest rates of summer meal participation in the country. With only 8.5% of children who receive free or reduced-price lunches during the regular school year also receiving free or reduced-price lunches during summer, Missouri ranks 44th in terms of summer meal participation (NCES, 2018). In terms of poverty, St. Louis City has a poverty rate of 25%, but this rate differs greatly across race and ethnicity; despite making up 45% of the City's population, Black individuals make up 64% of those living in poverty (United States Census Bureau, 2018). Conversely, St. Louis County has a poverty rate of just 10% (2018).

Similarly, this rate also differs greatly across race and ethnicity; despite making up just 24% of the County's population, Black individuals make up 45% of those living in poverty (2018).

Missouri public schools closed on March 20th, and on April 6th stay-at-home orders for St. Louis City and County were put in place that lasted until May 18th (Chetty et al., 2020). In response to COVID-19, Missouri has implemented many of the core federal policy provisions in order to maintain student meal access during the pandemic. These include the SFSP/SSO Area Eligibility Waiver, the Meal Time Waiver, the Non-congregate Feeding Waiver, and the Nationwide Parent/Guardian Meal Pickup Waiver. In doing so, meals at Seamless Summer Option and Summer Food Service Program locations are provided at no cost to children 18 and under, regardless of their household income (Missouri Department of Elementary and Secondary Education, 2020). Additionally, meal service times are unrestricted; meals do not have to be eaten at the sites; and meals do not have to be picked up by students themselves—allowing for less restricted access to meals during COVID-19 while simultaneously limiting disease transmission.

Theoretical Framework

The geography of opportunity is an analytical and theoretical framework in which “place” is central to understanding patterns in economic mobility, health, and its social determinants. This framework has strong roots in research that focuses on inequalities related to neighborhoods (Rosenbaum, 1995), housing (De Souza Briggs, 2005), and urban development (Squires & Kurbin, 2005). Recently, health and education researchers have begun to adopt this framework. For example, Acevedo-Garcia and her colleagues (2008) demonstrate that residential segregation is central to understanding disparities in access to opportunity neighborhoods that support healthy development with adequate transportation, high-quality healthcare, and

nutritious food options. While many conventional policy proposals involve improved access to opportunity-rich neighborhoods through relocation programs (i.e. people-based interventions), Acevedo-Garcia and her colleagues (2008) also recognize the importance of improving opportunities *within* disadvantaged neighborhoods (i.e. place-based interventions). The geography of opportunity framework in education research is also focused on place-based interventions. For example, Tate et al. (2012) examine the geospatial location of opportunities to learn science, technology, engineering, and math (STEM) in St. Louis, calling for increased opportunities to learn these skills in urban localities.

Our analysis exists at the intersection of health and education as it relates to the geography of opportunity. Like Acevedo-Garcia and her colleagues (2008), we focus on *opportunity neighborhoods* that allow for healthy development, which in this case is a neighborhood where the supply of school meals during COVID-19 meets the demand for low-income students. Like Tate and his colleagues (2012), we focus on the geospatial location of *opportunities to learn* by focusing on food, which is a core prerequisite to learning. Without adequate food, students may not be able to seize learning opportunities, and without providing equitable food access during a global pandemic, schools may ultimately not be able to provide students with these opportunities.

Recently, studies have incorporated detailed spatial analyses in the assessment of geographic opportunity and food security. Miller (2016) examined driving time to summer meal sites for households that filled out the California Health Interview Survey. Using a gravity model that takes into account both the supply of summer meals and the demand for them, this research found that geographic accessibility was associated with decreased probability of very low food insecurity among households with young children and households that lived in suburban, town,

or rural areas. In another study in Texas, Wilkerson et al. (2015) found that urban areas were more likely to have summer meal access points. We extend these studies by exploring how the geography of opportunity changes over time and in response to large-scale shocks, like the COVID-19 pandemic.

Methods

We estimate accessibility to free, school-sponsored meals before and during the COVID-19 pandemic in three ways. First, using the average number of meal access points, we demonstrate how meal accessibility before and during COVID-19 relates to both family poverty and supermarket access. Second, using Euclidean or straight-line distances, we demonstrate how meal accessibility relates to Free and Reduced-Price Lunch status. Finally, using a gravity-based model that considers both family poverty and the number of meal access points, we demonstrate how meal accessibility changed during COVID-19 and how this change relates to urbanicity and racial composition.

Our gravity-based model utilizes a 2-step floating catchment area (2SFCA) method to measure a catchment area of interest. Considering food research, measuring geographic food access can rely on measures of either proximity or density (Charreire et al., 2010). The proximity approach estimates the presence of spatial dependence between suppliers (e.g., grocery) and demanders (e.g., shoppers). The proximity approach, however, often neglects the fact that the number of accessible suppliers can be as significant as the distance to the nearest supplier. By contrast, a density approach estimates how the intensity of accessible suppliers varies over an area. The density approach typically sets a boundary (e.g., ZIP code area, Census tract, etc.) and measures density by dividing the number of suppliers in an area by its population or its land area. Nevertheless, the density approach can be prone to bias, as it tends to focus on either the

suppliers or the demanders. The density approach is also vulnerable to the Modifiable Areal Unit Problem (MAUP), which highlights the potential of bias in the arbitrary delineation of a spatial unit's boundaries (Chen, 2017).

To overcome the problems with both proximity- and density-based approaches, we employ a gravity-based accessibility method known as a Two-Step Floating Catchment Area (2SFCA) approach (Radke & Mu, 2000), which effectively combines the proximity and the density approaches. This approach has been used recently to investigate food access inequity for African Americans in Columbus, Ohio (Chen, 2017) and to evaluate the geographical accessibility to SNAP-authorized retailers in Arkansas (Chen, 2019).

In this study, the catchment area is the geographic area from which families are able to get food for their children (demand) from a meal access point (supply). The model consists of two steps. First, it measures each supplier's service intensity to their surrounding potential beneficiaries (families in poverty) within a given geographic boundary.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_o\}} P_k}$$

The service intensity of a food supplier j (R_j) is the function of the number of suppliers (S_j) and the number of beneficiaries in a census block group k (P_k) where the distance between its population center and the supplier (d_{kj}) is not greater than a determined bandwidth (d_o). We set S_j as 1 for every meal access point. For beneficiaries k (P_k), we used the number of families in poverty. Following the USDA's food access definition for urban areas (see Rhone, Ver Ploeg, Williams et al., 2019), we used a 1-mile bandwidth. The second step of this analysis sums the estimated ratios floating around each demand location—census block groups in our study. The accessibility score for a census block group i (A_i) is as follows:

$$\begin{aligned}
A_i &= \sum_{j \in \{d_{ij} \leq d_o\}} R_j \\
&= \sum_{j \in \{d_{ij} \leq d_o\}} \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_o\}} P_k}
\end{aligned}$$

All variables in this equation are defined as above. To conduct this analysis, we used ArcMap v. 10.6.1, and we used QGIS to produce all visualizations.

Data

The locations of meal access points in 2020 were downloaded from Missouri's Coronavirus GIS Hub (Missouri Department of Health and Senior Services, 2020). Meal access points for 2019 were obtained via request from the Missouri Department of Elementary and Secondary Education and via a Sunshine Law and Public Records Request from the Missouri Department of Health and Senior Services. Seamless Summer Option data from the Department of Elementary and Secondary Education were already geocoded. To geocode Summer Food Service Program data from the Department of Health and Senior Services, schools from the Department of Health and Senior Services dataset were merged with the Department of Elementary and Secondary Education school directory dataset, and data points that were not merged (e.g., those at community parks or town centers) were manually geocoded using Google Maps. Shapefiles for school districts, school buildings, census block groups, and census tracts were downloaded from the Missouri Spatial Data Information Service archive (Missouri Spatial Data Information Service, n.d.). Spring 2019 meal access points included any locations that served FRP meals during May. Spring 2020 meal access points included any locations that served FRP meals during May as well; however, in order to maintain consistency, spring 2020 meal access points were recorded during the first week of May *while* the spring semester was

still in session. Summer 2019 meal access points included any locations that served meals during the summer school session (late May through July). Summer 2020 meal access points included any locations that served meals during the first week of July.

We obtained family poverty data from the 5-year estimates of the 2018 American Community Survey. We downloaded population-weighted centroids for census block groups from the U.S. Census Bureau. Using the Census' continuous measure of family poverty, we also created a binary measure of family low-income (FLI) status that follows a common formula used by the Food Access Research Atlas (Rhone, Ver Ploeg, Dicken et al., 2017). Census tracts with poverty rates of at least 20 percent for families with children or median income for families with children at or below 80 percent of the metropolitan area or state median income were given a family low-income status.

We also used a measure that converges income with food access created by the Food Access Research Atlas. Combining low-income (LI) designations identical to our FLI designation with low-access (LA) designations, the Food Access Research Atlas created a status that measures the overlap of LI and LA census tracts—known as LILA tracts (Rhone, Ver Ploeg, Dicken, Williams, & Breneman, 2017). LA status is determined by the proximity to the nearest supermarket and accounts for differences in Urban and Rural areas. As noted by Rahkosky and Snyder (2015), “a tract is classified as low access if at least 500 people or 30 percent of residents live more than 1 mile from a supermarket in urban areas” (p. 6).

We obtained Free or Reduced-Price Lunch (FRPL) rates from the Missouri Department of Elementary and Secondary Education (DESE) and the Prime Center at St. Louis University (<https://www.sluprime.org/>). We categorized FRPL rates based on Community Eligibility Provision (CEP) criteria. In the state of Missouri, DESE provides the option to offer free meals

to all students in high-poverty schools (dese.mo.gov) through the CEP. As previous research demonstrated that a greater proportion of CEP schools adopt more innovative meal models, such as grab-and-go meals (see Operation Food Search, 2020), CEP eligible schools may be better equipped to provide food during the pandemic. In order to be eligible for CEP, schools must have at least 40% of students qualify for Free or Reduced-Price Lunches (FRPL). The percentage of students that qualify for FRPL is then multiplied by a factor of 1.6 to determine a free claiming percentage for the school. Thus, schools that have 62.5% of students that qualify for FRPL have 100% free meal claims.

Finally, we obtained population density and racial composition data from the 5-year estimates of the 2018 American Community Survey. For our population density measure we created quartiles for the total number of all people in a census tract; for our racial composition measure we created quartiles for the percentage of individuals who identified as Black in a census tract.

Results

1. How does meal access during COVID-19 relate to Free and Reduced-Price Lunch status?

Nearly half (46%) of the census tracts in St. Louis City and County are considered low-income—mirroring the state of Missouri (Table 1). Yet, due to the relative density of its residents and the proximity to grocery stores, only 10% of the census tracts are considered low-income low-access (LILA). Over half (53%) of the public schools in St. Louis serve a student population where at least 62.5% of students that qualify for free or reduced price lunch, which allows schools to serve free and reduced-price meals to all of their students under the Community Eligibility Provision. For schools located in low-income census tracts, the average proportion of students who are eligible for FRPL is 86%—compared to 39% for schools that are

not located in low-income census tracts. Similarly, for schools located in LILA census tracts, the average proportion of students who are eligible for FRPL is 79%—compared to 57% for schools that are not located in LILA census tracts. As seen in Figure 1, the majority of schools with the highest proportions of students that are eligible for FRPL occur in St. Louis City, as well as the northern suburbs in St. Louis County.

2. How did meal accessibility change during COVID-19?

Unsurprisingly, the average number of meal access points during the regular school year prior to COVID-19 (spring 2019) is over one in all census tract categories (Table 2). Essentially, all census tracts contain a school that serves free or reduced-price meals to students who need them. Moreover, when considering summer meals prior to COVID-19 (i.e., summer meals served in 2019), the average number of meal access points was much larger in low-income census tracts when compared to higher income census tracts: 35% compared to 13%. Nevertheless, in spring 2020 (during COVID-19), the average number of meal access points in low-income census tracts was only slightly less than the average number of meal access points prior to COVID-19: 0.94 in spring 2020 compared to 1.08 in spring 2019. In theory, students in low-income areas had similar opportunities to receive free meals during COVID-19 (spring 2020) as they did prior to COVID-19 (spring 2019). This, however, was not the case for students in higher income census tracts. Rather, the average number of meal access points was substantially less during COVID-19: 0.45 in the spring of 2020 compared to 1.22 in the spring of 2019. In the summer of 2020, the average number of meal access points nearly doubled to 1.76 in low-income census tracts when compared to the previous summer. Again, this was not the case in higher income census tracts where the average number of meal access points only slightly increased from summer 2019 to summer 2020. When considering income *and* food access

together, a similar trend emerged: the average number of meal access points in LILA census tracts substantially increased during COVID-19. In fact, there were more food access points in spring 2020 than there were in spring 2019 within LILA census tracts.

When we consider school districts, we see similar trends. Meal access points within school districts decreased from spring 2019 to spring 2020, yet increased from summer 2019 to summer 2020 (Table 3). Moreover, for schools with higher proportions of students that qualify for FRPL, the decrease from spring 2019 to spring 2020 was much smaller, while the increase from summer 2019 to summer 2020 was much larger. For example, among schools where at least 62.5% of the students qualify for FRPL, meal access points dropped from 21.0 in spring 2019 to 19.4 in spring 2020—compared to schools where less than 40% of the students qualify for FRPL, which experienced a drop from 12.5 in spring 2019 to 0.69 in spring 2020.

Conversely, among schools where at least 62.5% of the students qualify for FRPL, meal access points increased from 6.8 in summer 2019 to 32.5 in summer 2020, a substantial increase compared to schools where less than 40% of the students qualify for FRPL, which experienced an increase from 0.10 in spring 2019 to 1.60 in spring 2020

Similarly, average distances to the closest meal access points from schools increased from spring 2019 to spring 2020, yet decreased from summer 2019 to summer 2020. We also saw much shorter distances in schools with higher proportions of students qualifying for FRPL. For example, the distance to the closest meal access point in spring 2020 was 0.71 miles in schools where over 62.5% of the students qualify for FRPL—compared to 4.64 miles in schools where less than 40% of the students qualify for FRPL.

Finally, when considering both supply of and demand for meal access, measures from our 2SFCA analyses corroborate many of the previously mentioned trends. First, there was a

considerable drop-off in accessibility in the regular school year during COVID-19: meal accessibility in spring 2020 was roughly one-third the accessibility in spring 2019 (Table 4). However, the opposite trend occurred in the summer: meal accessibility in the summer of 2020 was over four times greater than the accessibility in the summer of 2019. When comparing the school years, accessibility decreased in the western and southern regions of St. Louis County, as well as the southwestern region of St. Louis City. At the same time, accessibility increased in the northern region of St. Louis County (Figures 2 and 3). However, when comparing the summers, accessibility primarily increased in the urban core in St. Louis City, the northern region of St. Louis County, and the region near the western boundary of St. Louis City. (Figures 4 and 5).

3. How do changes in meal accessibility during COVID-19 correspond to measures of race/ethnicity and socioeconomic status?

Finally, when considering the geospatial location of racial minorities, such as the percent of Black families (Figure 6), and how it relates to the geospatial location of expanded summer meal access (Figure 5), it appears that the practices implemented during COVID-19 have improved racial equity in meal access. This is confirmed when considering that the opposite pattern occurs in the Western (mostly non-Black) regions of St. Louis County and that accessibility did not increase in the southwest (mostly non-Black) region of St. Louis City. Accessibility also increased within and around lower income areas, as well as areas that had lower access (LILA) to food markets (Figures 7 & 8).

Discussion

The emergence of COVID-19 disrupted the U.S. economy, education system, and healthcare infrastructure. In this paper, we examined the effect of COVID-19 and resulting policy and program changes on school meal access in St. Louis, Missouri. Specifically, we

sought to understand how school meal program access continued during COVID-19 as schools changed to virtual formats and families faced a deep and sudden economic crisis. Federal and state policies and the response of school district leadership and administrators appears to have maintained meal accessibility for areas with high proportions of students eligible for free and reduced-price meal programs. This builds on recent findings from McLoughlin and her colleagues (2020), which examined the methods and strategies being implemented to optimize meal provision in large urban school districts.

In general, summer meal program access and participation traditionally have been significantly lower than school breakfast and lunch programs offered during the academic year, which may contribute to the observed increase in access during the summer opposed to the spring. While our analysis suggests that practices implemented during COVID-19 may have improved racial equity in geographic meal access, the observation of significantly lower access in higher socioeconomic areas suggests a barrier in access for households with lower incomes in these areas. Here, low-income students in middle- and upper-income schools—especially in more suburban areas—may face the largest barriers in food access during the pandemic.

This paper contributes to literature in several ways. In one of the first analyses of its kind, we employ a two-step floating catchment area analysis to analyze school meal accessibility changes over time—an approach that accounts for both the number of meal access points within a given geographic region *and* the number of families living below the Federal Poverty Level. This novel approach will serve as an example for how to utilize two-step catchment to understand geographic inequalities in other education, public health, and specifically food insecurity related areas.

We also extend the application of the theoretical and analytical framework of the geography of opportunity to the study of food access in urban and suburban areas. While this framework has been utilized in health, education, and urban development, we broaden its use to understand inequalities in food access. Place matters, and following previous studies that have examined disparities between geographies, our findings suggest that geographic access to school meal distribution points in St. Louis City and County is reflective of the areas with the greatest likelihood of having children and families eligible for free and reduced price meals.

Finally, we add to the growing and important literature on school meals (Weaver-Hightower, 2011). By highlighting students' access to basic needs, such as food, during COVID-19, we provide school leaders, policymakers, and other researchers with a lens to view other sources of inequities during and after COVID-19. Our results have clear implications for policy development and program interventions to ensure children have access to food during times when they are not in school. Prior to the global pandemic, summer food program policies were restrictive and served as a barrier to participation both for providers and food insecure families. While it should not take a global pandemic to come up with new ways of getting meals to low-income families, this blueprint will be valuable for moving forward in a more equitable manner.

Given the current availability of data, this study is not without limitations. One limitation of our analysis was not having data available to include a comparison of the number of meals served. The analysis also does not account for access to other emergency food supports through government programs or the charitable food system. Lastly, the analysis does not account for differences within access points, such as the number of days and hours they are open. As additional data do become available, future research can complement our examination of geographic access to meal distribution points by considering the number of meals provided and

comparing the observed transition of the school meal ecosystem in St. Louis, MO, to other metropolitan areas in the United States. Future studies may also examine access and utilization of meal and food supports during COVID-19 including Pandemic-EBT, SNAP, and USDA Farmers to Families Food Box Program.

Conclusion

Families in the United States were living with increasing susceptibility to financial shocks even prior to the COVID-19 pandemic, and the U.S. education system has only had mixed success in addressing the persistent food insecurity experienced by children and their families. Food insecurity is one of many significant barriers that remote learning poses for K-12 education and may exacerbate other inequities such as household technology and connectivity, learning environments, and instructor training and preparedness. As previous research demonstrates connections between nutrition, school performance, and educational outcomes, maximizing continued access to a critical source of meals is paramount for advancing educational and health equity both during the current pandemic and beyond. The expansions and policy innovations around school and summer meal programs due to COVID-19 have provided the infrastructure from which to mitigate increased food insecurity. Extending several of the newly implemented policies such as the SFSP/SSO Area Eligibility Waiver, the Meal Time Waiver, the Non-congregate Feeding Waiver, and the Nationwide Parent/Guardian Meal Pickup Waiver beyond COVID-19 should be a priority policy consideration to address childhood food insecurity.

Table 1*Overview*

Category	Missouri		St. Louis	
	Number	Proportion	Number	Proportion
Low-Income Tracts	642	46.1%	139	45.6%
LILA Census Tracts	247	17.7%	31	10.2%
Free and Reduced Price Lunch (FRPL)				
Schools with 0-39.9% Students Eligible	601	27.9%	122	35.6%
Schools with 40-62.4% Students Eligible	746	34.7%	39	11.4%
Schools with 62.5-100% Students Eligible	804	37.4%	182	53.1%

Table 2*Food Need and Access by Census Tracts*

Category	Low-Income	Non-Low-Income	LILA	Non-LILA
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
St. Louis				
Average FRPL Eligibility Proportion	0.86 (0.27)	0.39 (0.34)	0.79 (0.33)	0.57 (0.39)
Average # of Meal Access Points				
Spring 2019	1.08 (1.16)	1.22 (1.17)	1.06 (1.06)	1.16 (1.18)
Summer 2019	0.35 (0.89)	0.13 (0.40)	0.26 (0.58)	0.23 (0.69)
Spring 2020	0.94 (1.19)	0.45 (1.19)	1.19 (1.45)	0.62 (1.17)
Summer 2020	1.76 (1.68)	0.63 (1.35)	2.06 (2.37)	1.04 (1.47)

Table 3*Food Need and Access by Schools*

Category	<u>School FRPL Eligibility Categories</u>		
	0-39% FRPL Elig.	40-62.4% FRPL Elig.	62.5-100% FRPL Elig.
	Mean (SD)	Mean (SD)	Mean (SD)
St. Louis			
Average Number of School Meal Access Points (in District)			
Spring 2019	12.5 (9.31)	5.67 (3.79)	21.0 (31.00)
Summer 2019	0.10 (0.32)	0.33 (0.58)	6.80 (10.70)
Spring 2020	0.69 (0.84)	2.00 (2.65)	19.4 (28.65)
Summer 2020	1.60 (1.35)	2.67 (2.31)	32.5 (46.35)
Average Distance to Closest School Meal Access Point (from Schools)			
Spring 2019	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Summer 2019	4.64 (2.44)	1.93 (1.99)	0.71 (0.73)
Spring 2020	3.28 (2.33)	0.50 (0.71)	0.38 (0.40)
Summer 2020	2.24 (2.02)	0.45 (0.63)	0.26 (0.29)
Number of Schools	122	39	182

Note: All distance cells for Spring 2019 have values of zero because all schools served at least some free and reduced price meals

Table 4*Accessibility Measure*

Category	<u>Two-Step Floating Catchment Area Measure</u>					
	Average	1 st Quartile	Median	3 rd Quartile	Minimum	Maximum
St. Louis						
Spring 2019	0.0200	0.0057	0.0110	0.0229	0.0000	0.1967
Summer 2019	0.0026	0.0000	0.0000	0.0034	0.0000	0.0909
Spring 2020	0.0068	0.0000	0.0038	0.0088	0.0000	0.0747
Summer 2020	0.0110	0.0000	0.0085	0.0160	0.0000	0.0849

Figure 1. Free and Reduced Price Lunch

Notes: St. Louis City is the area east of the red line. St. Louis County is the area west of the red line. Dots represent Free or Reduced Price Lunch categories from the 2018-2019 school year.

Figures 2 and 3. Meal Accessibility (2SFCA): Spring 2019 (Top); Spring 2020 (Bottom)

Notes: St. Louis City is the area east of the red line. St. Louis County is the area west of the red line. Dots represent food access points. Darker shades represent greater accessibility.

Figures 4 and 5. Meal Accessibility (2SFCA): Summer 2019 (Top); Summer 2020 (Bottom)

Notes: St. Louis City is the area east of the red line. St. Louis County is the area west of the red line. Dots represent food access points. Darker shades represent greater accessibility.

Figure 6. Percent Black Population

Notes: St. Louis City is the area east of the red line. St. Louis County is the area west of the red line. Darker shades represent greater proportions of Black residents.

Figures 7 and 8. Low-Income (Top) and Low-Income & Low-Access (Bottom)

Notes: St. Louis City is the area east of the red line. St. Louis County is the area west of the red line. Darker blue shades represent greater proportions of residents in poverty. Low-income-low-access (LILA) census tracts are in red.

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