Geospatial Reach of the Maryland COVID-19 School Meals Response: Spring 2020

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ABSTRACT

Objective: Examine characteristics of pandemic meal site (n = 602) location and meals served per site in Maryland, Spring 2020, following federal/state waivers for local meal site placement decision-making.

Methods: Using geographic information systems, we connected meal sites to census tract-level data and generated service areas from sites and distances from population-weighted census tract centroids to the closest pandemic meal site. Regression analysis determined associations of census tract pandemic meal site count and meals served per site with socioeconomic and demographic variables.

Results: Census tracts with more meal sites were urban ($P < 0.001$), food deserts ($P < 0.001$), and had higher percentages of children in poverty ($P < 0.001$). Sites serving fewer meals were in food deserts ($P < 0.001$) and areas with more children in poverty ($P < 0.001$).

Conclusions and Implications: Waivers allowing local meal site placement decision-making supported meal sites in high-need areas. Geospatial approaches could optimize site locations to ensure maximum reach to populations in need. Additional supports may be needed to ensure children in poverty areas receive meals distributed at these sites.

Key Words: COVID-19, school meals, GIS, urban, poverty (*J Nutr Educ Behav.* 2022;54:957−963.)

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic emergency forced many schools in the US to close for an extended period. These unanticipated closings disrupted access to nutritious meals for the more than 29 million children from low-income families who usually access the US Department of Agriculture's (USDA) school-based federal nutrition assistance programs (eg, *National School Lunch Program*, *School Breakfast Program*).[1−3] Reports suggest a sharp decline in school meal program participation during the early pandemic.[4] This decline in school meal access, particularly when combined with gaps in access to other food sources and worsening family economic situations, may have exacerbated food insecurity rates and disparities in the US.[2,5,6]

School districts nationwide responded to the pandemic by adjusting school meal delivery to students.[5,7] Many of the strategies were made possible because of a variety of temporary federal and state waivers, which enabled flexibilities to the existing policies to support continued program operations.[1,8] In Maryland, the *Emergency Provision of the Summer Food Service Program* was operated to meet the state mandates for school breakfast[1] and lunch.[2] Waivers allowed local districts to choose where to locate sites and where meals would be distributed, rather than site location being dictated by area income eligibility. As a result, local program staff could choose the locations on the basis of their knowledge of the layout and needs in their community.

Despite the federal government's flexibility, school meal participation decreased overall during the pandemic.[4] The geographical characteristics that define whether specific groups of children could reach the program are not well-understood. Understanding these trends is essential to define food insecurity exacerbations and design and implement targeted strategies to better reach children in under-accessed areas during the COVID-19 pandemic recovery period and during other emergencies that might disrupt school meal access and other planned periods of school closures (eg, summer).

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Key dimensions of food access include availability (adequacy of the supply of healthy food) and accessibility (the location of the food supply and ease of getting to that location, typically measured by geographic distance).[9] Few studies have examined the reach (which factors in availability and accessibility) and geographical distribution of pandemic school meal sites. McLoughlin et al[10] examined meal program sites across large urban districts. They found that most sites were not located in low-income areas or USDA-defined food deserts, where students may have inadequate access to healthy food options and could be more dependent on school meals to meet dietary needs.[10] The McLoughlin study only focused on the location of sites in large urban districts. It did not examine differences in meals served by eligibility characteristics or site placement across diverse geographic or socioeconomic areas.

Therefore, the primary goal of this study was to use a multimethod geospatial analysis to examine factors associated with access to pandemic meal site distribution across Maryland in spring 2020. Factors of interest include access to meal sites across the urban/rural continuum and socioeconomic and demographic characteristics, including population density of school-aged children, percent of children in poverty, and food desert status.

METHODS

School Meal Sites

We obtained school locations and pandemic *Emergency Provision of the Summer Food Service Program* school meal distribution sites (spring 2020) from the Maryland State Department of Education. Each site had a physical address and accompanying data regarding the number of meals served per site (breakfast, lunch, supper, and snack). We geocoded all meal sites that provided meals during school closures (n = 656) and school sites (n = 1,420) using a batch geocoding service called BatchGeo, which uses Google Maps application programming interface to determine the geographic location of each site. Geocoding was performed to the highest accuracy possible to reduce measurement error. We conducted geospatial analysis in ArcGIS (Environmental Systems Research Institute, ArcMap, release 10.7) using the geocoded school meal sites. We divided school meal sites by urban/rural designation on the basis of a spatial join of site point locations with the National Center for Education Statistics area level urban/rural classification. To measure the reach of the meal sites in the community, we created road network-based services areas, called early pandemic meal site catchment areas, for each school meal site using the Environmental Systems Research Institute (2021) ArcGIS Online network analysis service. This service calculates distances across road networks as a realistic estimate of typical travel behaviors by private motor vehicle transportation and may represent walking along with road networks, including sidewalks. For urban sites, services areas were 1 or 3 miles. For rural sites, service areas were 5 or 10 miles. We determined these distances on the basis of reasonable travel estimates from the USDA regarding urban and rural travel for food,[11] and typical food procurement travel patterns indicated from previous research.[12]

Census Sociodemographic Information

We used a spatial join to connect meal site locations with relevant geographic and sociodemographic datasets to determine availability for different sociodemographic groups. We obtained census tract-level data from the US Census Bureau's American Community Survey, 2014−2018 (5-year estimates). The sociodemographic variables of interest in this study were the total school-age population (aged 5−19 years) and percent poverty (% of households with income below the poverty level). We examined the total school-age population to understand access as it related to potential demand, and the percent of children in poverty variable was chosen to examine socioeconomic disparities in access. Because school meal distribution sites could be pulling children from across census tract administrative boundaries, we grouped census tract sociodemographic data within a certain distance of meal site locations (urban, 3 miles; rural, 10 miles).

Food Desert Status

We extracted food environment data from the USDA Food Access Research Atlas to understand the food environment context of the meal site locations and examine it as an indicator of healthy food access. This data included food desert census tracts, defined as low-income and low-access tracts measured at 1 mile for urban and 10 miles for rural areas. To measure the availability of meal sites in food desert areas, we connected food desert data to census tract mapping files. We then used a spatial join to connect pandemic meal sites to generate a total count of meal sites per census tract for food and nonfood desert designated census tracts. To measure the accessibility of food desert areas to meal sites, we calculated the road network distance (based on potential private transportation or walking along with road networks) from food desert census tract centroids (representative center to capture overall accessibility within the tract) to pandemic meal sites using the Environmental Systems Research Institute closest facility road network analysis service.

Distance to Pandemic Meal Sites

To measure accessibility from population-weighted centroids to a meal, we generated the estimated travel distance and travel time from population-weighted census tract centroids to the closest pandemic meal site sites (based on potential private transportation or walking along with road networks) using the closest facility analysis in the ArcGIS Spatial Analyst Toolkit. Population-weighted census tract centroids were pulled from the Integrated Public Use Microdata National Historical Geographic Information System at the University of Minnesota. Geometric centroids from high poverty areas (≥ 20% percent childhood poverty) to the closest pandemic meal sites were generated. We also calculated distances from high poverty census tract centroids and the centroid of aggregated census tracts to meal sites.

Meals and Reach

Maryland State Department of Education provided the number of students eligible for free or reduced-priced meals within each school. We connected this data to a geographic information systems (GIS) layer containing meal site locations. Breakfast and lunch meals were the only meals included because almost all sites served breakfast and lunch during school closures. Before the pandemic, Maryland had a state mandate to operate a free and reduced-price lunch program at all public schools and operate breakfast at all elementary schools, including a free breakfast program in some schools called *Maryland Meals for Achievement* (schools can apply if 40% of their students qualify for free or reduced-price lunch).[13,14] We defined percent as the number of meals served during school closures (April and May) divided by the number of free or reduced-price meals served in January and February when schools were open.

Data Analysis

Before analysis, we aggregated GIS and administratively derived data into a dataset and then checked the dataset for alignment and accuracy. We calculated the percentage of Maryland public schools located in the early pandemic meal site catchment area of the pandemic meal sites. We also calculated the percentage of students eligible for free or reduced-price meals who attend school in the early pandemic meal site catchment area of the pandemic meal sites, using 1 or 3 miles for urban sites and 5 or 10 miles for rural sites. The catchment areas were based on what the USDA deems as reasonable travel distances to a supermarket of 1-mile distance in urban locations (given potential issues with transportation among disadvantaged populations) and 10-mile driving distance in rural locations. The USDA defines medium walking accessibility as within 1-mile walking distance and high rural driving accessibility as within 10 miles.[11] We combined the early pandemic meal site catchment area (3 miles in urban areas, 5 miles in rural areas) into a single layer to determine the percentage of Maryland's total land area covered by an early pandemic meal site catchment area. We used Mann-Whitney U tests and ANOVA to examine sociodemographic differences in census tracts with and without meal sites.

A negative binomial regression model was used to examine the associations of meals served at each site (outcome) and predictor variables, including census tract sociodemographic variables (total school-aged population, percent of children in poverty), urban status, and census tract food desert status. A spatial lag regression model (spatially lagged dependent variable to account for spatial autocorrelation (dependent variable is dependent on its neighbors); weights matrix queen contiguity, 1 order) was used (because of a significant Lagrange multiplier lag value in GeoDa) to examine the association between the number of meal sites per census tract (outcome) and predictor variables of the total school-aged population, the percent of children in poverty, urban status, and census tract food desert status. This protocol was reviewed by the University of Maryland, Baltimore IRB and deemed exempt.

RESULTS

Coverage (Total, Urban, Rural)

There were 602 pandemic meal site locations in Maryland, with 76.2% (459 out of 602) within the National Center for Education Statistics designated urban areas. A total of 34.9% (438 out of 1,384) census tracts in Maryland contained pandemic meal sites. There was an average of 0.48 ± 0.81 meal sites per census tract, with a range of 0−7 sites. Among census tracts with sites, there was an average of 1.4 ± 0.8) sites per tract. There was an average of 8,595 ± 14,423 meals served by the site.

Distance to Sites from Census Tract Population Centroids

Table 1 summarizes the road network distance from population centroids to pandemic meal sites overall and by urban/rural designation. The average distance from population centroids to pandemic meal sites was 2.0 ± 1.9 miles or 4.5 ± 3.7 minutes. Distances and time were shorter for urban areas compared with rural areas. The average distance from the service area aggregated geometric centroids to the closest pandemic meal site was 0.77 ± 0.91 miles and 2.5 ± 2.0 minutes. All centroids of service area aggregated high poverty census tract sites were within 1 mile of the closest pandemic meal site.

Sociodemographic Characteristics of Areas With and Without Sites

In the census tracts with high childhood poverty (> 20%), 54.1% (78 out of 144) had a school meal site. A summary of demographic and socioeconomic differences in meal site vs nonmeal site census tracts can be found in Table 2. Compared with census tracts without meal sites, census tracts with meal sites had a statistically significant higher rate of total school-aged population ($P < 0.001$) and school-aged children below poverty ($P < 0.001$).

Table 1. Road Network Distance from Population Centroids to Pandemic Meal Sites Overall and by Urban/Rural Designation

Variables	Overall	Urban	Rural
Miles	2.0 ± 1.9	1.6 ± 1.4	4.0 ± 2.6
Minutes	4.5 ± 3.7	4.8 ± 3.1	8.0 ± 4.5

Note: Values are presented as mean ± SD.

Table 2. Sociodemographic Characteristics by Census Tract Meal Site Availability

Sociodemographic Variable	Meal Site	No Meal Site	*P*
Total school-aged population	1,170.2 ± 602.3	1,036.0 ± 586.2	< 0.001
% Minority	44.9 ± 31.0	43.8 ± 31.7	0.34
% Poverty	13.4 ± 10.3	9.0 ± 9.0	< 0.001
Child poverty population	177.1 ± 177.5	87.3 ± 114.8	< 0.001

Schools and Students in Early Pandemic Meal Site Catchment Areas

Table 3 summarizes schools and students in early pandemic meal site catchment areas, and the Figure 1 displays a service area map. More than half of Maryland schools (53% and 68%) were within the more proximal urban or rural early pandemic meal site catchment areas of 1 or 5 miles, respectively. Nearly all schools were within the extended urban or rural early pandemic meal site catchment areas of 3 and 10 miles, respectively (86% and 89%). Similarly, more than half of the eligible students for free or reduced-priced meals attended a school located within a more proximal early pandemic meal

Table 3. Percent of Maryland Public Schools within an Early Pandemic Meal Site Catchment Area and Students Eligible for Free or Reduced-Price Meals Who Attend School in Early Pandemic Meal Site Catchment Area

	% Maryland Public Schools within Catchment Area				% Eligible Students within Catchment Area			
Site	1 mile	3 miles	5 miles	10 miles	1 mile	3 miles	5 miles	10 miles
Urban	53	86	–	–	66	94	–	–
Rural	–	–	68	89	–	–	70	92

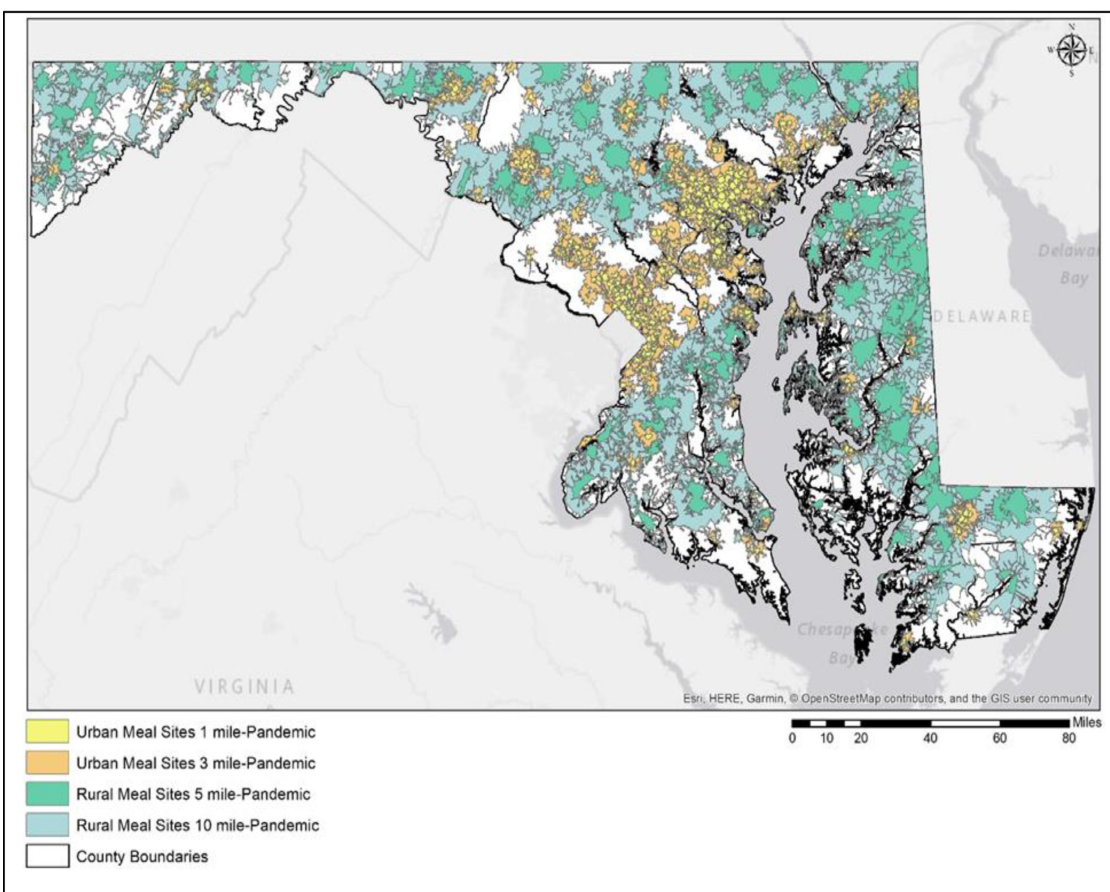

Figure 1. Pandemic meal site service areas (road network) by US Department of Agriculture urban and rural designation.

site catchment area in urban and rural communities (66% and 70%). Nearly all children who received free or reduced-price meals attended schools within 3 or 10 miles in urban and rural communities, respectively (94% and 92%).

We found that 51.0% (6,314 out of 12,407) of Maryland's land area was within an early pandemic meal site catchment area. Of this area, 22.8% was urban area (1,437 out of 6,314) and 77.2% (4,877 out of 6,314) was rural area.

Proximity of Meal Sites to Food Deserts

There were 74 food desert census tracts with pandemic school meal sites, representing 56.5% (74 out of 131) of food desert census tracts. The average distance from food desert centroids to pandemic meal sites was 1.84 ± 2.18 miles and 5.07 ± 4.06 minutes, with urban locations (n = 127) averaging 1.62 ± 1.38 miles and 4.68 ± 2.83 minutes, and rural locations (n = 4) averaging 8.70 ± 6.88 miles and 17.25 ± 11.4 minutes. There were no statistically significant differences between food desert and nonfood desert locations by school-aged population count, but there was a statistically significant greater percentage of child poverty ($P < 0.001$) in food desert locations vs nonfood desert locations.

Regression Analysis of Meals Served

A summary of the regression analyses can be found in Table 4. In the negative binomial model of meals served, there was a statistically significant inverse association between meals served and food desert designation ($P < 0.001$) and the number of children in poverty ($P < 0.001$), such that there was a higher number of meals served in nonfood desert census tracts (average of 9,120 ± 15,659) vs food desert tracts (average of 6,126 ± 5,303), and higher number of meals served in areas of lower levels of poverty. There were positive, statistically significant associations between meals served and the school-aged population ($P < 0.001$), such that more meals were served in areas with a larger population of school-aged children.

Spatial Regression Analysis of Meal Site Density

The Moran's I value was 0.203 ($P = 0.001$; $z = 12.8$), meaning that the spatial distribution of high and/or low values in the dataset was more spatially clustered than expected if underlying spatial processes were random.[15] In the spatial lag regression model of meal site density, there was a statistically significant inverse association between school meal site density per tract and urban/rural designation ($P < 0.001$), such that there were fewer meal sites in more rural areas. There was a statistically significant positive association between meal site count and food desert status ($P < 0.001$) and the percentage of children in poverty ($P < 0.001$), such that there were more meals sites in areas with a greater total school-age population, areas with food deserts, and increased numbers of children in poverty.

DISCUSSION

Our findings suggest that Maryland School Nutrition leadership and collaborating community meal site directors chose meal site locations in areas of highest need on the basis of population and free or reduced-price meal participation. Although most census tracts did not contain meal sites, most meal sites (in urban and rural areas) were within a reasonable distance of schools and students eligible for free and reduced-price meals. We found that school-aged children in urban and rural locations were mostly within or near this threshold on the basis of accessibility to private transportation or walking along with road networks.

The ability to decide on meal site placement at the local level stemmed from federal and state waivers. This allowed local districts to choose where to locate sites where meals would be distributed, rather than site location being dictated by area income eligibility. Based on our findings, this flexibility seems to have allowed local program staff to choose effective locations on the basis of their knowledge of the layout and needs in their community; however, there were instances in which this appeared inadequate.

Our findings were similar to previous research on summer nutrition programs. Turner et al[16] examined summer food service programs in California and found that meal sites were mostly located in higher population

Table 4. Associations Between Meals Served by Site and Meal Site Density

Independent Variables	β	SE	Z	P
Model no. 1[a]				
Child percent poverty rate (census tract)	−0.09	0.02	−4.42	< 0.001
Food desert (vs nonfood desert)	−0.43	0.09	−4.61	< 0.001
School-aged population (census tract)	0.03	0.004	6.40	< 0.001
Urban (vs rural)	0.60	0.09	6.91	< 0.001
Model no. 2[b]				
Child percent poverty rate (census tract)	0.04	0.004	10.02	< 0.001
Food desert (vs nonfood desert)	0.29	0.06	4.28	< 0.001
School-aged population (census tract)	0.004	0.002	1.66	0.07
Urban (vs rural)	−0.22	0.06	−4.0	< 0.001

[a]Dependent variable is the number of meals served per meal site; [b]Dependent variable is meal site density per census tract.

density and higher poverty areas.[16] Our study also found closer proximity of meal sites to higher population density and higher poverty areas. The similarities between pandemic and summer meal sites may be due to previous experiences with summer meal sites and what were deemed successful site locations to reach populations in need.

We found that the presence of pandemic meal sites in food desert locations was slightly higher than what has been found in previous research.[10] This finding is important as children living in food deserts likely have inadequate access to healthy food options and could be more dependent on school meals to meet dietary needs. Furthermore, we found that poverty levels were a significant explanatory variable for meal site location. However, fewer meals were served in those higher poverty areas after controlling for the school-aged population. This finding suggests that simply placing a meal site in a high-need area may not be enough.

A limitation of this study is the lack of individual-level residential address data to assess individual-level accessibility more accurately. Our analysis also does not factor how districts may have used spatial or sociodemographic information to determine pandemic meal site locations. Our study examined walkability on the basis of distance but did not factor in walkability factors like sidewalk conditions or nonroad network routes, which may be influential to access. Our GIS distance models were also based on private transportation and potentially walking along with road networks but did not examine accessibility by public transportation. Our study focused on availability and accessibility, but other dimensions of food access may be important, including accommodation and acceptability. Because of the need to use existing secondary datasets from the US Census Bureau and USDA that did not exactly align with project dates, the combined dataset for analysis used data covering different years, which may have impacted the accuracy of sociodemographic and food environment information.

Although this study used the phrase food desert defined by USDA Economic Research Service, we acknowledge that residents and leaders of community groups in these areas report experiencing this term as pejorative.[17] The term may reinforce underlying structural inequities that affect healthy food access and may be antithetical to working toward solutions for culturally appropriate and sustainable access to healthy food options in historically marginalized communities.[17]

IMPLICATIONS FOR RESEARCH AND PRACTICE

This detailed geospatial examination of COVID-19 pandemic meal sites, including information regarding meals served, provides insight into meal site placement and distribution under federal and state waivers that lifted area eligibility criteria when determining the location of a meal site. The information gathered in this study can inform future summer food service programs or school meal distribution during other unanticipated school closures (natural disasters, etc). It is essential to have pandemic meal sites be reasonably accessible to children in need, and future approaches could allocate meal sites to maximize reach for the most vulnerable populations. Placing meal sites in underserved areas within walking distance and walkable and in locations accessible to public transit may improve access to and use of the meal sites during school closures, particularly given potential issues with transportation among disadvantaged populations.[11] These factors could be driving the discrepancies we found in this study between the location of the meal site and the number of meals served. The influence of geospatial factors across varying geographic locations and situational contexts must be studied beyond the COVID-19 pandemic period.

Research that examines individual-level accessibility and site usage data, including physical addresses from relevant points of origin (home, work, etc), would help locate sites to meet child needs more precisely. Mixed-methods research may also be beneficial to understanding the context of food distribution during a pandemic or other emergency from both food service staff and families.

There is a need to know how districts may have used spatial or sociodemographic information to determine pandemic meal site locations and how they could use this information. Future program development and policymaking could use geospatial approaches to optimize site locations to ensure maximum reach to populations in need. Equitable communication strategies,[10] innovations in meal delivery options,[5] and optimized geospatial allocation modeling could inform future community meal delivery.

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