Washington DC and Baltimore, MD: A Study of Two Food Deserts

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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A common flaw associated with historical analysis is the presumption of a distinct turning point regarding a historical movement or entity, as these indicators tend to ignore the previous actions associated with that entity. For instance, the 1967 Detroit riots are frequently associated with the collapse or decline of Detroit, while Detroit became dysfunctional at earlier points (Thompson, 1999, p. 168). Specifically, the decline of racial relations and effective city governance caused the damage experienced in 1967 to be long-lasting (Thompson, 1999, p. 168). Similar ties can be defined with Washington, DC and Baltimore, MD with the reduction in taxes and commercial activity corresponding with increases in crime associated with the COVID-19 era, with budget cuts already substantially impacting the Washington Metro Area Transit Authority (WMATA) operations (Dempsey, 2021) and substantially declining median home prices in Baltimore coupled with a previously unstable home market (Merrill, 2021). While these effects are more severe for Baltimore, given that it lacks the stable US federal government tax base of Washington, DC and its transit system, Washington, DC is not perfect regarding food desert mitigation either (Smith, 2017). Previous recent analyses have also been conducted on the food deserts of both areas, but these studies are limited in scope by typecasting the demographics used and no equivalent study using cellular location study is known to have been conducted unlike Washington State (McDermot et al., 2017, p, 131).

A more complete approach can be achieved by using the actions of people within these areas regarding the locations they frequent for food and the behaviors associated with these visits to guide an analysis of the policy decisions for each area and their effectiveness in mitigating food desert issues. Actor-Network Theory (ANT) -an analytics framework which presents a group or environment as a network of actors and actants- is an ideal lens for identifying the present issues with food desert mitigation in the Washington, DC and Baltimore, MD metro

areas. The effectiveness of ANT can be enhanced by including a key actant associated with both food desert and food access issues and previous applications of ANT: food store businesses (Bedore, 2012, p. 146) As common trends can be observed with the formation of food deserts and food access issues in the form of groups such as transportation or zoning agencies (Bedore, 2012, p. 143), a more individualized approach is needed given the differing political and economic environments of the Washington, DC and Baltimore, MD metro areas. Given these details, a complete analysis would identify the unique relationships between the citizens, the transportation and/or low-income outreach elements of local governments, and food stores (restaurants and grocers excluding night clubs, bars, and other alcohol-based or event venue businesses) specific to each metro environment. The heterogeneous nature of food desert environments reflective of the unique economic and political situations for each region required an individualized ANT assessment for both the Washington, DC and Baltimore, MD metro areas which was enhanced with population-level behavioral and demographic data. This analysis was supplemented by the 2010 US Census, the Food Access Research Atlas, and a cellular location dataset consisting of more than 30,000 anonymized users across both metro areas. A contrast between the Washington, DC and Baltimore, MD metro areas is used because of their geographic proximity, similarity in location tracking availability, and the possible insights achievable by studying the different managerial styles of the cities given their different employment environments (Chapman, 2020, p. 2).

Food Access: Policy and Citizenry

Fundamental to the issues of maximizing quality food access is reducing the difficulty of traveling to healthy food establishments and the operation of these sorts of generally lower-margin businesses in an accessible area to citizens (Shank, 2013). Washington, DC as the

operator of the WMATA has encountered substantial success in utilizing its overarching transit system to effectively mitigate food desert problems throughout much of the metro area (Kortum, 2017). However, the weakness of the city's strategy becomes apparent when observing food accessibility at the fringes of the metro area such as northern and southeastern Washington, DC (Izadi, 2011). At these fringes which are not adequately serviced by transit offerings such as MetroRail or MetroBus, food accessibility from a transit level falters (Miller, 2018). Washington, DC's present approach is to use incentives to encourage outside businesses to establish stores in areas which could impact the accessibility of food for food desert residents (Miller, 2018). These incentives can enable businesses to be established in topically relevant places to food desert residents, but these funds have previously been ineffective in mitigating

food desert issues, given that the Ward 7 and 8 food desert problem has persisted as indicated in Figure 1 (Shank, 2013).

Baltimore, MD has a more severe dysfunction regarding food desert mitigation. Specifically, a key element of the city's history has been a failure to communicate and coordinate with potential actants such as media, potential food store operators, or transit systems (Mossburg,

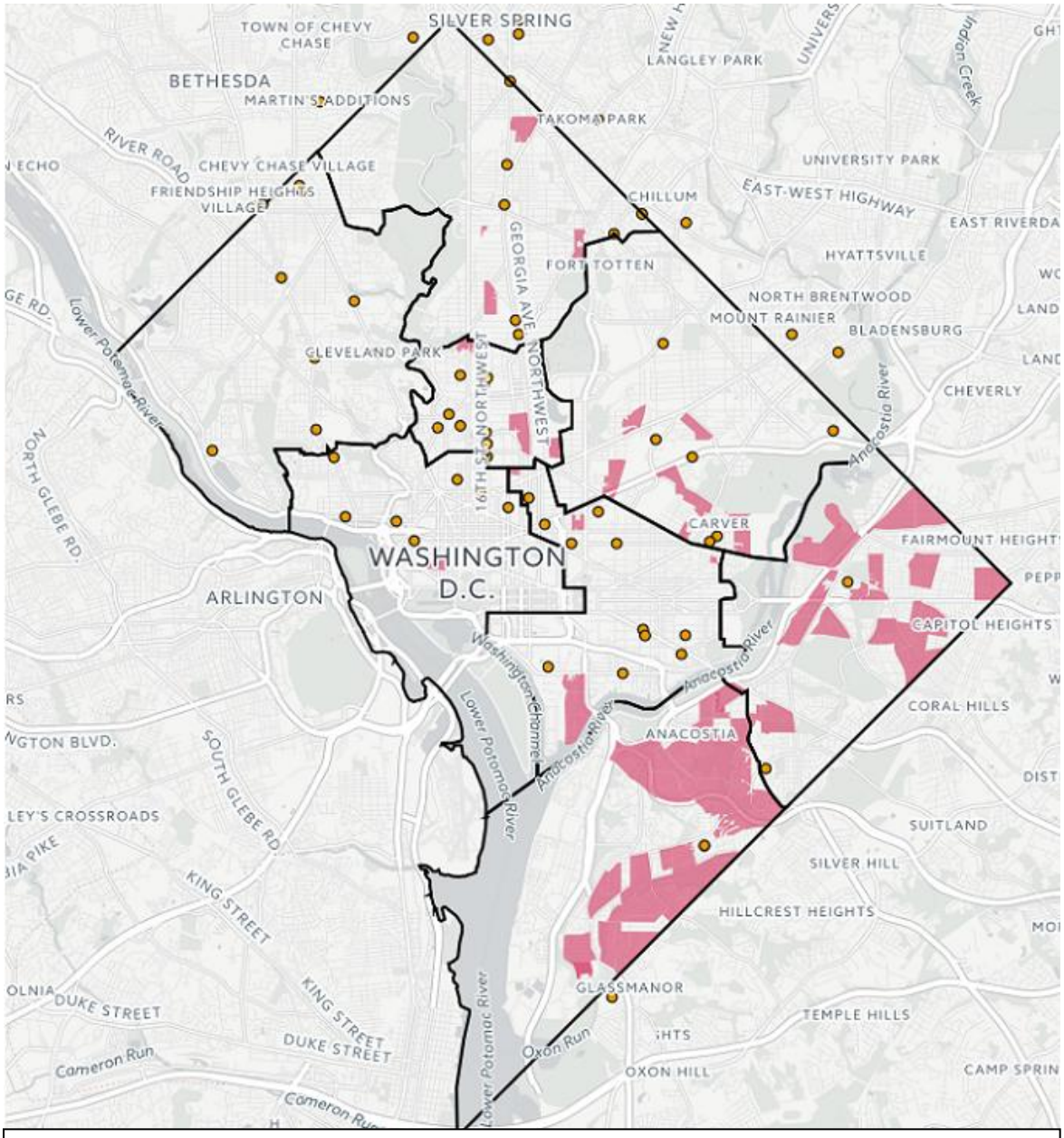

Figure 1: Food Deserts in DC, 2017: A map of food desert regions and other problem areas based on car availability, location beyond half a mile from a grocery store, and elevated poverty rates (Smith, 2017).

2019). While Baltimore, MD does implement a transit system in the form of its Charm City Circulator bus system, bus systems are not desirable to citizens because of convenience issues (Miller, 2018). More recent efforts associated with Baltimore are addressing these issues using targeted establishments acting like grocers to provide healthy foodstuffs such as urban gardens (Delgadillo, 2017). However, these efforts are likely to encounter setbacks given nationwide declines in commercial activity which directly impact tax revenue. This has already impacted some establishments critical to preventing food desert origination such as the closure of Save-A-Lot in Eastern Baltimore, which limits the access of Broadway East, Oliver, and Johnston Square citizens to healthy foods (Leonard, 2020). Some of Baltimore's disparity in how it addresses food deserts could be explained by its more meager and less stable tax base caused by the reduced prominence of federal employees and the reduced median income of the metro area (Mossburg, 2019). This reduced income, however, does not explain the lack of intent from the Baltimore local government associated with mitigating these issues.

One major element which is present in the Baltimore, MD efforts to mitigate food deserts which are not present in the Washington, DC metro area (at least in equivalent strength) is the prevalence of non-governmental community outreach efforts such as Food Rescue (Koch, 2019). These community outreach efforts, given their reduced funding, are generally targeted efforts such as food pantries or farmer's markets (Chen, 2020) and transit systems to other healthy food stores (Leonard, 2020). While the action of communities to mitigate these sorts of food access concerns provides a material impact on the prevalence of food access issues, the scope of these efforts is oftentimes lacking particularly in the central areas of food deserts because of the insufficient coordination of such efforts with local governments regarding funding (Leonard, 2020). These efforts contrast to the more established farming efforts established in cities such as

Washington DC through collaboration with specialized actants such as BrightFarms both in the stability and the sustainability of such measures (Shank, 2013).

Given the differing food desert environments and attempted mitigations, the food deserts of the Washington, DC and Baltimore, MD metro areas appear to be differentiated by both the communities and governments of these metro areas. While Baltimore, MD's metro area lower and moderate-income citizenry demonstrates a more overt interest in mitigating food desert issues, these community-led responses are hampered by a lack of funding to increase the density of these services or a transit system to make these services be accessible over a longer distance. In comparison, Washington, DC's metro area citizenry does relatively little to address these concerns as potential actants while the city government is attempting to gradually expand its transit system to address these concerns along with a greater willingness for food store investment given the amount of traceable store openings from April to September 2019 (2) in comparison to the Baltimore, MD metro area (0). The result for such efforts is similar, however. These efforts fail to convince actants such as health-oriented food stores to invest in areas which could materially impact quality food access or leverage the media in campaigns to increase awareness of these issues (Choudbury et al., 2016, p. 1168). With an enhanced explanation of the general pitfalls to food access and an analysis of resident activity in both metro areas, a more precise set of causes can be identified for these previously noted food access concerns.

Food Access: Deserts and Swamps

Because of the increasing prevalence of food deserts associated with stagflation, various means of measuring food deserts have been defined, with some of the first metrics focusing on the distance between the general population and grocers (Shaw, 2003, p. 11). As the practice of developing means of classifying food deserts has evolved, additional criteria were added such as

the income of a given area (Shaw, 2003, p. 12). This metric which has primarily been championed by the U.S. Department of Agriculture Economic Research Service emphasizes the proximity of users to a grocer using two different distances based on the housing area and the area's median income. In urban areas, this distance is generally 20 times less than the rural area distance, accounting for the increased likelihood that users would not be using individually owned or driven vehicles (U.S. Department of Agriculture Economic Research Service). The main flaw with this metric is that its use implicitly assumes that the food quality is no longer an issue once the accessibility of the population in transport and economic circumstance to grocers is resolved (Hager et al., 2016, p. 2604). Demographic behavior can differ from this assumption, as the quantity of unhealthy restaurants or the lack of knowledge on healthy food vendors (restaurants or grocers) could cause residents to have an inaccurate picture of the local food environment (Dubowitz et al., 2015, p. 1866). These food swamps further complicate the process of identifying locations where healthy food is accessible, as they tend to exploit the behaviors of their residents to pursue unhealthy food sources despite accessible healthy sources (McGuirt et al., 2018, p. 10).

An alternate metric created to account for these behavioral factors is the mRFEI: a metric which indicates the ratio of healthy food stores to the overall count of food stores in the area (Gustaffson et al., 2012, p. 3). Food stores can include a variety of locations, ranging from healthy and unhealthy restaurants, grocers, convenience stores, food banks, among other locations (Salinas & Sexton, 2015). However, the mRFEI is far more difficult to calculate and the mRFEI values for different regions can differ based on the kinds of restaurants that are being used (Salinas & Sexton, 2015). Users of the mRFEI could use various combinations of restaurants to calculate the statistic, and the only means of identifying a fully transferrable

mRFEI is by using a uniform classification system of healthy stores for the regions which are being compared and all food stores for each region are included in this statistic. Such a measure is not necessary for this comparison, as the similarity of the prevalence of retail chains in the Washington, DC and Baltimore, MD metro areas means that a reduced listing of food stores can be used. There are still gaps in this approach, however, as some regions within both metro areas lack sufficient store counts to calculate the mRFEI statistic. This issue primarily impacts the Washington, DC metro area, as 22% of the users in this metro area reside in a region with an incalculable mRFEI, while this issue is much less prevalent in the Baltimore, MD metro area at only 5% of its users. Because of these limitations associated with the mRFEI, the statistics collected primarily rely on the food desert indicator enumerated with statistics such as the distances users travel to various food store types.

A Dataset Summary

The dataset being used for this study encompasses the activity of 37,766 users, with 16,814 (44.52%) of these users with identifiable home locations in the Washington, DC metro area and 20,952 (55.48%) of these users with identifiable home locations in the Baltimore, MD metro area. Of this user set utilizing the Food Access Research Atlas, 15,306 users were found to have home locations which were within food deserts existent according to the 2010 US Census and the 2015 FARA. The overwhelming majority of these users with home locations in food deserts were present in the Baltimore, MD metro area (10,254 or 66.99% of the food desert sample), while a smaller subset of users (5,052 or 33.01% of the food desert sample) was present in the Washington, DC metro area. Comparing these user counts to the demographics of both metro areas according to the 2010 US Census, the proportion of desert to non-desert citizens is approximately identical, with 48.94% of Baltimore, MD metro area users being resident to food

deserts in comparison to 49.27% of the population of the Baltimore, MD metro area being residents of food deserts. Similarly, the Washington, DC metro area user base proportion of 30.05% of users being resident to food deserts is approximate to the 2010 US Census population proportions for the Washington, DC metro area of 30.43% of the Washington, DC metro area population.

Additionally, the commercial activity of 463 stores in both the Baltimore, MD and Washington, DC metro areas was captured for users in this sample, with 315 of these stores in the Washington, DC metro area and 148 stores in the Baltimore, MD metro area. Of these stores, 67 (21.27% of the Washington, DC metro area store sample) of these stores were in food deserts in the Washington, DC metro area and 53 (35.81% of the Baltimore, MD metro area store sample) were situated in food deserts in the Baltimore, MD metro area. These stores for each metro area were divided into three categories: grocers, healthy restaurants, and unhealthy restaurants. The specific distribution of these restaurants including indicators for how many of these restaurants were in food deserts is depicted in Figure 2 on p. 10. For the users in this study,

a series of metrics were tracked on the behavior of the population: the number of visitor-days (quantity of days where a user is found within the radius of the store) associated with each individual store, the number of visitors to each individual store, and the number of unique stores visited by users. In total, 704,442 visitor-days were identified, with distributions for these visitor

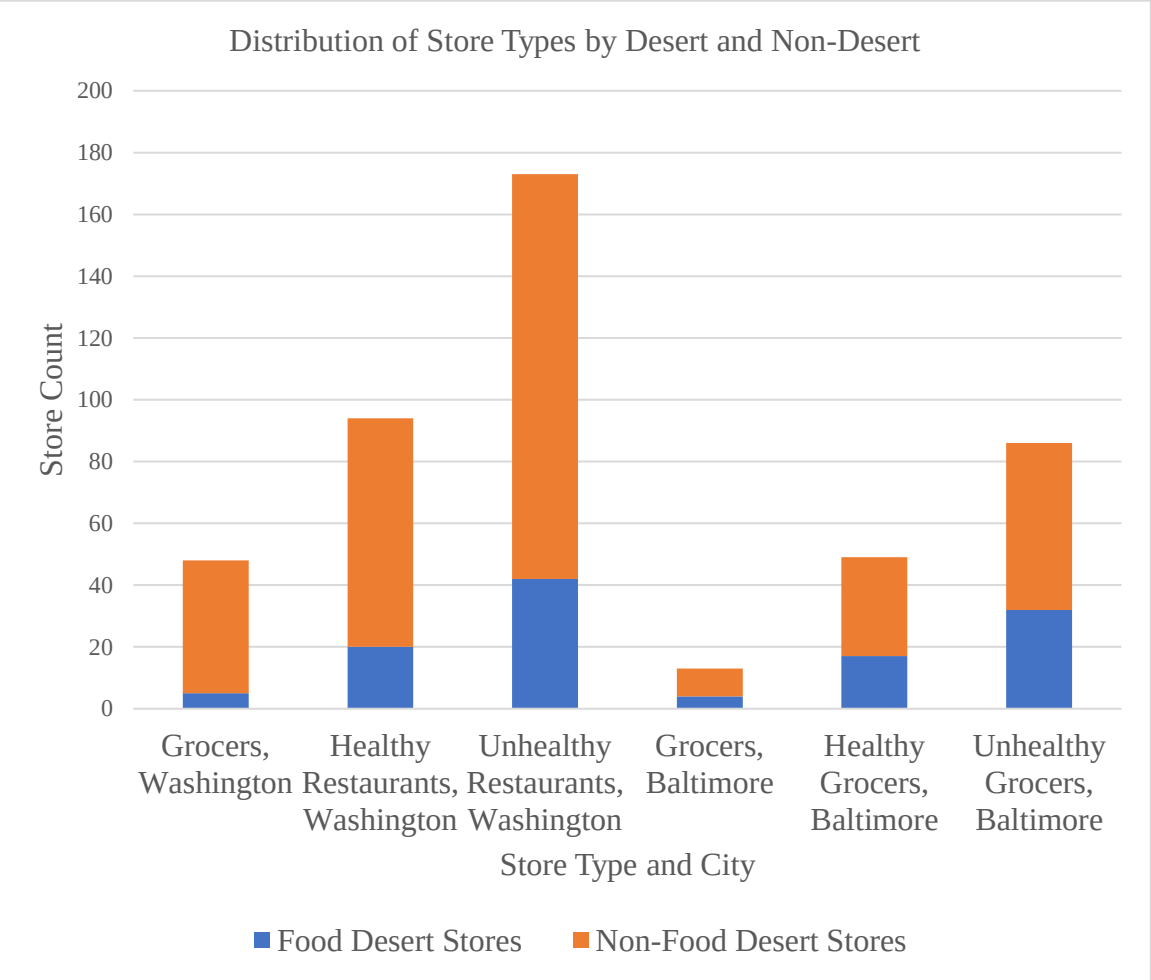

Figure 2: Distribution of Store Types by Desert and Non-Desert: The distribution of stores by metro area, type, and presence in a food desert. This store listing is not a complete listing of stores for each type in the metro area and are restricted to the brands of stores that are considered valuable (not publicly disclosable).

days present in Figure 3 on p. 11. Active users were also identified for each store category, each

metro area, and for food desert and non-food desert resident users. Lastly, the distributions for the quantity of all stores visited by users were collected.

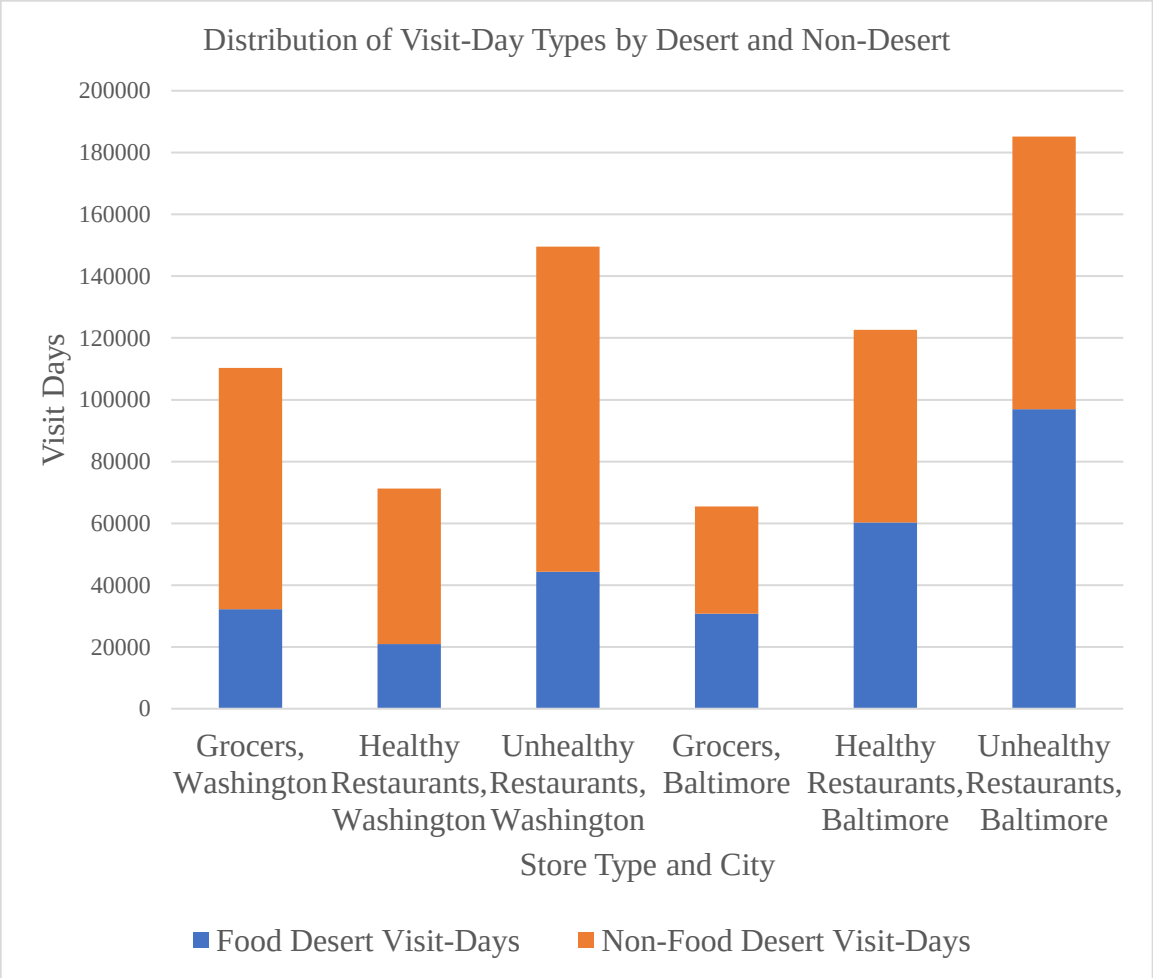

Figure 3: Distribution of Visit-Day Types by Desert and Non-Desert: The distribution of visit-days (quantity of days a user visits a store within the study's scope) by metro area, type, and whether the visitor's home location is in a food desert. This store listing is not a complete listing of stores for each type in the metro area and are restricted to the brands of stores that are considered valuable (not publicly disclosable).

Alongside these statistics on group restaurant visitation, metrics on the distances users traveled to reach food stores were collected with statistics on two food store openings in the Washington, DC metro area to be used as case studies: the opening of a Chick-fil-A in a desert region and the opening of Trader Joes in a non-desert region. These statistics were collected for users living within three miles of these stores and additional metrics were collected for store

activity within three and ten miles of each store. Both case studies involve Washington, DC metro area residents as most constituents and are meant to assess the behavioral changes associated with the introduction of a grocer to a non-food desert area (Trader Joes) and an unhealthy restaurant in a food desert area (Chick-fil-A) to better understand the significance of citizen interaction on the perpetuation or mitigation of food access issues.

Consumer Activity to Stores

One of the first details that was observed from this dataset was that lower-margin businesses such as grocers and healthy restaurants were significantly less prominent per user in the Washington, DC metro area. For instance, grocers were 3.7 times less common per user in food deserts than in non-desert areas. This trend was reflected with the count of healthy restaurants per user (1.59 times less common in food deserts) and unhealthy restaurants (1.34 times less common in food deserts). This trend is also present in Baltimore with its grocers (2.16 times less common in food deserts), healthy restaurants (1.80 times less common in food deserts), and unhealthy restaurants (1.62 times less common in food deserts). Additionally, for all store variants, they were fewer stores per user in the Baltimore, MD metro area, with stores being 2-2.2 times less per user than in the Washington, DC metro area. Similarly, the number of visit-days per store is inflated for Baltimore, MD metro area users compared to Washington, DC metro area users to extents which frequently exceed the above store presence metric. For instance, the average visit count per Washington, DC mero area grocer was 2,381.02 per store, while the equivalent statistic for the Baltimore, MD metro area was 5,451.67, a 229% difference between the two areas. This pattern is also present for healthy and unhealthy restaurants, reflecting the effects of reduced store availability. These availability concerns appear to match with the lags in response that the Baltimore city government in either encouraging increased food store activity in the city or combating the overtly demonstrated resident activity towards unhealthy restaurants and away from grocers as indicated in Figure 2 on p. 10 (Trickley, 2020).

These store visitation issues are more overt with the visit-days normalized to the populations of the Washington, DC and Baltimore, MD metro areas, respectively. As indicated in Table 1 on p. 14, visitation to unhealthy restaurants per user is dramatically higher in the

Baltimore metro area than in the Washington, DC metro area. Given that the Washington, DC metro area user sample consisted of 30.05% food desert residents and the Baltimore, MD metro area user sample consisted of 48.94% food desert residents, these user percentages reflect a heavily elevated food desert user visitation rate for unhealthy restaurants in the Baltimore, MD metro area. Similar inferences can be made on the percentage of desert visitors to grocers between both areas as indicated in Table 2, but the disparity in food desert user vs non-food desert user activity is not as severe as with the unhealthy restaurants in Table 1.

Table 1: Per-Metro Area Distributions for Visitor -Days from Various User Types to Unhealthy Restaurants: The percent compositions of visitor-days (the quantity of days a user is present at a store) for users from food deserts versus users not from food deserts for unhealthy restaurants in the Washington, DC and Baltimore, MD metro areas.

	Washington Unhealthy Restaurants	Baltimore Unhealthy Restaurants
Visitor-days from food desert users per restaurant in non-food desert	29.60%	46.59%
Visitor-days from food desert users per restaurant in food desert	29.63%	65.16%
Visitor-days from food desert users	29.61%	53.50%

Table 2: Per-Metro Area Distributions for Visitor-Days from Food Desert Users to Grocers: The percent compositions of visitors (users which visited at least one store for at least one day) for users from food deserts versus users not from food deserts for grocers in the Washington, DC and Baltimore, MD metro areas.

	Washington Grocers	Baltimore Grocers
Visitor-days from food desert users per store in non-food desert	29.56%	42.02%
Visitor-days from food desert users per store in food desert	32.43 %	57.65%
Visitor-days from food desert users	29.86%	46.83%

The overall worse metrics for food desert activity when controlled for the metro area user count or the metro area population also appear to correspond to endemic issues associated with the management of Baltimore, MD (Mossburg, 2019). A general trend was also captured that metro areas which had worse food desert issues (more of the population was found to live in food deserts) tended to have more food desert user overrepresentation in store types, potentially reflecting a transportation difficulty which the Washington, DC metro area did not have at the time (Baltimore City Department of Planning, p. 2). Given the very high visit-day per grocer figure for Baltimore, MD metro area grocers, it would make sense that the city has placed more effort into addressing a lack of grocers or grocer-like stores given more recent projects to add grocers or grocer equivalents (Kleerman). However, given that a substantial amount of these outreach efforts are gardens, while these efforts might be successful at placing a large amount of potential healthy food sources at a low cost, either more gardens will need to be established or the transportation issues in Baltimore need to be addressed given that transportation problems bottlenecked previous garden implementations (Wang et al., 2014, p. 131).

Distance behaviors regarding visitor travel to food stores was also recorded, but the relation of these to food access, as no other study directly integrates commute distances into food desert assessment, is less clear. In general, median commute distances to Baltimore, MD metro area food stores was less than commute distances in the Washington, DC metro area, which is likely caused by the inferior Baltimore transit system which only utilizes a bus network in comparison to Washington, DC's MetroBus and MetroRail systems (Widener, 2018, p. 259). For instance, median transit distances to grocers in food deserts was virtually identical for residents in food deserts at a median distance of 7.65 miles for food desert residents and 7.64 miles for residents not in food deserts. Greater disparity was observed with grocers not in food deserts,

where residents in food deserts had to commute an average of 1.76 miles further than residents not in food deserts to access a grocer not in a food desert. In comparison, an evident disparity in access to grocers in food deserts is present for the Baltimore, MD metro area as median transit distances for grocers differ by 0.37 miles for food desert-based grocers with food desert-resident visitors with the shorter distance.

The Washington, DC Metro Area Case Studies

The Trader Joes and Chick-fil-A case studies indicate the relative impact that increased healthy food store presence has on an area mostly outside of a food desert and an unhealthy food store in an existing food desert, respectively. One of the first indicators of difference is the quantity of unique visitors and visits to these stores from residents living within three miles of the store. Chick-fil-A had a unique visitor-day and visitor count of 191 (105 desert-resident visitors, 86 non-desert-resident visitors) and 335 (1.96 visitor-days per desert-resident visitor, 1.5 visitor-days per non-desert-resident visitor) respectively while Trader Joes had equivalent values of 158 (9 desert-resident visitors and 149 non-desert-resident visitors) and 303 (1.67 visitor-days per desert-resident visitor,1.93 visitor-days per non-desert-resident visitor). These metrics reflect demographics of, for the three-mile radius surrounding these newly opened stores, of 1,958 (1,037 visitors resident in food deserts, 921 visitors not resident in food deserts) users for the unhealthy food store and 2,683 (77 users resident in food deserts, 2,606 users not resident in food deserts) users for the healthy food store. Adjusting the above figures for the sample population of the new food store, the advantage the unhealthy food store has in early-life traffic is better illustrated. The unhealthy food store has a local visitor per local user count of 9.75E-2 and the healthy food store has a visitor per local user count of 5.89E-2, indicating a 1.66 times higher local visitor count per local user. When expanding this count of unique visitors and visitor-days

to the entire Washington DC dataset, 453 unique visitors (214 desert-resident visitors, 239 non-desert-resident visitor) and 698 visitor-days (1.73 visitor-days per desert-resident-visitor, 1.37 visitor-days per non-desert-resident visitor) are identifiable for the unhealthy food store and 376 unique visitors (161 desert-resident visitors, 215 non-desert-resident visitors) and 568 visitor-days (1.71 visitor-days per desert-resident visitor, 1.36 visitor-days per non-desert-resident visitor) are identifiable for the healthy food store. Given the reduced increase in visitors when expanding the userbase to the entire metro area for the new grocer, the increased importance of adjacency in overall user population is illustrated, while the increased prevalence of visitors not from food deserts for the unhealthy food store seem to indicate a greater access to transportation from non-food-desert-resident visitors.

When observing food store activity within various radii of these stores, cumulative effects on the commercial food store environment can be observed. For instance, within a ten-mile radius of the Chick-fil-A store, the quantity of unique visitors to all stores increased, with the greatest individual store group to increase being unhealthy restaurants. Specifically, the quantity of unique visitors to unhealthy restaurants increased by 181 while grocer visitors increased by 129 and healthy restaurants increased by 101 users. Similarly, the number of visitor-days increased the most for unhealthy restaurants in this same radius by 2,309 visitor-days with grocers increasing by 1,184 visitor-days and healthy restaurants increasing by 933 visitor-days. When considering the radius of stores within a ten-mile radius of the Trader Joes, the net increase in visitors was not as severe, with grocers increasing by the smallest quantity of 353 visitors, while 377 new visitors appeared at healthy restaurants and 481 new visitors appeared at unhealthy restaurants. Regarding visitor-days, these also increased for all establishment types, but the grocer type was not the most prominent at 4,081 more visitor-days

(1,219 visitor-days from food desert visitors, 2,862 visitor-days not from food desert visitors), with a more pronounced increase in visitor-days to unhealthy restaurants (5,368 more visitor-days, 1,880 visitor-days from food desert visitors and 3,488 visitor days not from food desert visitors). Furthermore, much of these increases in grocer visitation were to grocers which were not in food deserts (3,461 visitor-days to grocers not in food deserts, 440 visitor-days to grocers in food deserts), likely indicating that the increasing grocer visitation is not financially enriching the food desert areas which could encourage future, more sustainable investments in food stores (Chen, 2020).

Citizens, Governance, and ANT Inferences

While a common facet of the food desert issues is transportation issues in both the Washington, DC and Baltimore, MD metro areas, the metro areas differ in how transit is an issue and additional factors associated with transit system use and the specific demographics which are responding to or failing to respond to food desert issues. With the behavioral data for the Washington, DC and Baltimore, MD metro areas, improved assessments on how citizens interact with food stores and the demographic circumstances of such citizens can be made. A pattern of low to middle-income citizen involvement has previously been identified, with a significant focus on establishing food stores independent from conventional food store businesses or an improvised transit network to other food store businesses (Leonard, 2020). As the stores measured in this study consisted only of major chains, activity to these locations was out of scope. However, the behaviors which were captured regarding food store distances better indicates the reason for these transit-system-like efforts in Baltimore, MD. As the distances traveled by Baltimore, MD metro area citizens is significantly less than the distances traveled by Washington, DC metro area residents while the food stores per capita for Baltimore, MD metro

area citizens in comparison to Washington, DC metro area citizens is significantly less, this would imply that food store visitation behavior is caused by an inability to travel further to alternate food stores, drastically increasing the activity of Baltimore, MD metro area food stores to study participants. Transit efforts such as the utilization of Lyft to get low-income Baltimore, MD residents to another grocer following reflect some understanding of this transit flaw but appears to be conducted insufficiently to amend these access issues (Leonard, 2020). The increased willingness of Baltimore, MD metro area citizens in food deserts to visit unhealthy food stores relative to equivalent demographics in the Washington, DC metro area also implies that the unhealthy food store businesses through supporting both sustained activity and a large quantity of unhealthy food store locations are an actor regarding quality food access issues. Additionally, as indicated with the Washington, DC metro area case studies, this tendency towards unhealthy food stores could increase with the wrong king of business interaction favoring unhealthy food stores which are more likely to be run successfully in low food access areas than grocers or other healthy food stores. The local government could also be included in this assessment as an actor because of its inability to present incentives for healthy food store activity. Figure 4 illustrates the ANT model for attempts to mitigate Baltimore, MD metro area food deserts, where low to middle-income citizens as actors attempt to impact change to food desert circumstances, while the complacency of food store businesses and local government outreach and transportation as actants prevent more effective mitigations for

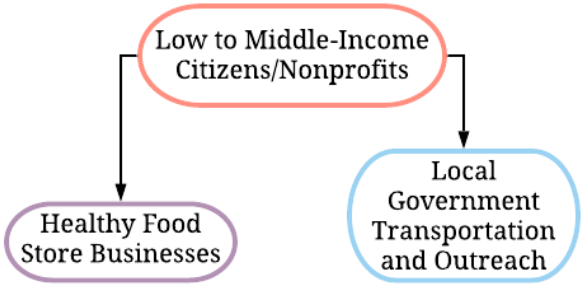

Figure 4: Baltimore, MD Metro Area Food Desert Mitigation Actor Network: A visual display of the primary actor (orange) with primary actants (blue and purple) which is not currently sufficient to address food desert issues in the metro area because of insufficient actant activity.

food deserts in the Baltimore, MD metro area from being realized. Additionally, because of the probable behavioral tendency of such residents to frequent unhealthy restaurants with the expansion of access to such restaurants

The effects of the Washington, DC metro area's transit circumstances are also enumerated with this data, but the saturation of food desert-resident food stores by food-desert-resident citizens is much less severe, implying that a transit issue still exists, but is not as severe as in the Baltimore, MD metro area. As there is insufficient information to evaluate the proportion of vehicles in the districts of Baltimore, MD, or the metro area, it is not possible to verify if this is caused by differences in vehicle ownership. A lack of both citizen action with equivalent organization to Baltimore, MD metro area efforts and WMATA action on resolving transit issues to Washington, DC metro area food deserts can be actor-like, but referring to relevant governmental entities tied to Washington, DC as a primary actor such as the WMATA is more appropriate. The greater quantity of centralized funding and the previous investments the WMATA has made as the operator of the Washington, DC metro area transit system makes it more influential than current citizen activities. As indicated in Figure 5, the Washington, DC metro area approach to food desert mitigation differs considerably from the Baltimore, MD metro area by not including significant civilian involvement and primarily relying on the WMATA to be an actor with healthy food store businesses responding to its changes to region access as an actant. This approach is deficient, however, in encouraging healthy

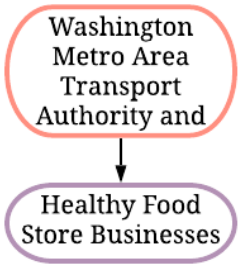

Figure 5: Washington, DC Metro Area Food Desert Mitigation Actor Network: A visual display of the primary actor (orange) with primary actant (purple) which is not currently sufficient to address food desert issues in the metro area because of insufficient actant activity.

food store activity in food deserts or effectively expanding the WMATA to encompass these food deserts enabling food desert residents to access healthy food stores more effectively. Given these indicators on how these metro areas are attempting to resolve food desert issues, a more precise summary of potential solutions to refine these actor networks can be detailed.

Informed Strategies and Conclusions

The reduced effects of food desert grocer visitation given the opening of a grocer in an area distant form food deserts (3+ miles) indicates that efforts to mitigate food deserts by increasing store counts must be more precisely targeted at existing food deserts. Furthermore, the extent these locations must be targeted at food deserts differs based on the transportation quality of the metro area. In the case of Washington, DC, because of its more developed public transit infrastructure, these locations can be placed with less density as residents could use a quality transit system to both reach these locations and overcome their interest in unhealthy food stores. However, Baltimore's reduced transit infrastructure means that a greater number of locations are needed to address these issues. This does not necessarily mean that more equivalent-sized healthy food stores are necessary, but that more food stores that have a more localized clientele than equivalent Washington DC stores are needed. The place of citizens as actors in this system is to encourage government investment in higher-quality transit systems and food store business incentives or governmental food store initiatives. Additionally, citizens should attempt to minimize visits to unhealthy food stores given the substantial increases in cumulative unhealthy food store visits to food desert regions in comparison to healthy food store visitation in non-food-desert regions. By coordinating with healthy food store businesses as actants (giving priority to grocers and grocer-equivalents because of the reduced visitation of healthy restaurants), expansions in quality food access can be more organic and able to adapt with the

changing economic and cultural circumstances of the metro area. The place of media in this relation would be to improve information on these changes in food access to both improve the diets of residents and ensure that these food store initiatives (businesses or non-profit efforts) can reach capacity quickly.

To focus more precisely on each metro area, the Baltimore metro area needs to improve the quantity of healthy food stores given the severe disparity in per-store visitation for grocers specifically. Given the scale of this disparity, the best long-term option would likely be to incentivize food store businesses in the Baltimore metro area primarily through government intervention. The citizenry could then have a role in raising awareness of these access changes or implement their own means of making their ward or district more ideal for business activity without excessively compromising the culture of these areas such as with neighborhood watches (Chen, 2020). As public transit system improvements would likely require a high amount of time and expense and the budget of Baltimore's city government is reduced pe capita in comparison to Washington DC, outsourcing expenses to businesses would be an ideal means to improve food access without putting the city's financial future in jeopardy or risking a large infrastructure project which the city cannot fully commit to.

While Washington DC's food deserts are significantly less prominent than Baltimore's food deserts, Washington DC has less in the form of community outreach efforts to assist these areas (Schwartzman, 2017). Specifically, the new businesses which are appearing in the metro area are either too far from the food deserts to aid them more extensively or are unhealthy food stores which will not impact the citizens' ability to get healthy food (Shank, 2017). Given that the WMATA's ability to expand is already limited by recent reductions in funding indicated by budget cuts to the WMATA (Dempsey, 2021), focusing on the quantity of food stores near to

residents instead of expanding the transit infrastructure to make more stores accessible to residents will likely be more feasible. Citizen-based community outreach would also help, but it will likely take time for these efforts to approach the size of more contemporary Baltimore initiatives, so the ideal action of citizens would be to pressure the Washington DC government to address this concern expediently.

It is important to note the limitations of these findings and some future efforts which can be taken to measure these metro areas more accurately. Firstly, the population metrics and food desert indicators are not current to the cellular location dataset and user activity. The Food Access Research Atlas used was from 2015, the most current version presently available, but the cellular location data capture is from April to September 2019. Location analytics could also be focused on specific areas of each metro area such as Wards seven and eight in Washington DC. A more inclusive listing of food stores can also be developed to better account for small businesses and other, smaller food store chains. Additional food store categories could also be integrated such as food banks or farmer's markets with such an expansion. However, given the insular nature of cellular location data collection in general and the reduction of academically accessible cellular location data through groups such as X-Mode (Sonnemaker, 2020), it is unclear what entity might be able to implement these expansions. There might be a time where cellular location tracking may need to be an opt-in process but given the high amounts of users which had to be rejected from this dataset for reasons of insufficient residence or presence indicators (95%), it is highly likely that these studies will not compose an equivalently general sample population. Fortunately, the use of this cellular dataset is ongoing and additional metrics are being computed at this time such as Washington DC and Baltimore-focused machine

learning models on food desert trends and other, targeted observations which can be derived on this dataset.

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