Defining Baltimore's Greenspace-Health Link in the Context of Redlining

Travis Lageman [a]
University of Maryland Baltimore County, Department of Geography & Environmental Systems

[a] 211 Sondheim Hall, 1000 Hilltop Circle, Baltimore, MD 21250
tlagema1@umbc.edu

Abstract

Literature on greenspace and its benefits to public health are in abundance. Studies have demonstrated mostly positive associations between increased greenspace and improved health outcomes in urban areas. While direct causal pathways are elusive to assuredly define, general consensus exists that a greater quantity of greenspace will lead to improved social, economic and environmental well-being. As such, many urban areas have shifted towards pro-greenspace policies as a remedy for problems exacerbated by urbanization and histories of segregation/discrimination. Yet, while planners and researchers recognize that each city has a unique history and present day state, studies on the relationship between greenspace and health have not included historical legacies of segregation/discrimination. Baltimore City is one such city where greenspace is at the forefront of urban planning, yet no study examines the relationship between greenspace and health for Baltimore specifically. This paper aims to fill this gap, while also adding in novel considerations such as redlining and quality of greenspace in hopes of providing insight for responsible greenspace planning like the city's recent *Green Network Plan*. Results of this study show no significant relationship between managed public greenspaces (parks and community managed open spaces) in terms of total square feet or number of spaces and self-reported physical and mental health. Instead, socioeconomic factors reported by an Area Deprivation Index (and age for mental health) standout, demonstrating poorer health as socioeconomic status worsens. This may urge planners and academics to rethink a greenspace-fits-all approach, and remember to address socioeconomic problems to improve public health.

Keywords

Baltimore, greenspace, health, GIS, redlining, policy;

Introduction:

Greenspace has been, and continues to be, an important component of urban planning. In the 18th century, parks were viewed as places to counter the incivility of the city (Byrne & Wolch, 2009) while present day planning efforts recognize the myriad environmental, social and economic effects that greenspaces have on cities, from drawing in visitors to helping adapt to impacts of climate change (Anguluri & Narayanan, 2017). With the world continually experiencing the effects of urbanization, greenspaces will undoubtedly become ever more critical in urban planning. One of the many boons of greenspaces that researchers have noted are its benefits to human health, both physically and mentally. Reviews of greenspace literature identify various studies that positively link more greenspace to improved health outcomes (Markevych et al, 2017; Van Den Beg et al, 2015). This research is salient in current literature and is continually being explored; even the United States Department of Agriculture-Forest Service recently published a report highlighting the impact that nature has on human health to help urban planners and other stakeholders communicate the health benefits of greenspace (2018).

Most greenspace-health studies are Geographic Information System (GIS) based using vegetation indices or distances to greenspaces to relate to health outcomes, but there are certain caveats to acknowledge. One issue is that access to a greenspace is conflated with proximity when defining access is more complicated (Markevych et al, 2017). A study, for example, may define greenspace access as a park within a certain minimum distance of a residence. However, this ignores other possible factors that may influence whether or not that individual actually accesses that park like quality or safety. Another caveat to acknowledge is that these studies cannot prove causality due to the nature of confounding variables (i.e. income, housing status, other poverty-related indicators) and lack of true, natural experiments. Therefore, while many pathways are posited for describing the mechanisms in which greenspace influences human health outcomes (Kuo, 2015; Markevych et al, 2017), these pathways are not definitively proven.

Despite this uncertainty there is general consensus that greenspace positively impacts public health, thereby making it critical for urban planners to understand how greenspace impacts *their* cities and its residents. This is particularly true given the fact that each city is unique, and has its own history that has shaped, and continues to shape, its modern-day form. No one would compare Baltimore to San Francisco, for example, as the two are drastically different cities presently and historically. For this reason, urban planners need to understand how greenspace specifically influences public health outcomes in their own respective cities in order to best inform policy decisions regarding greenspace. In the case of Baltimore City, this is particularly salient to the recent adoption and implementation of the Office of Sustainability's Green Network Plan (2018). This policy intends to build a network of existing and new greenspaces for residents' use while also capturing the myriad economic, environmental and other benefits that greenspaces provide cities. Therefore, it should be concerning that no such study exists for Baltimore City with this recently launched policy, with the exception of a survey based greenspace-perceived stress study using a non-representative sample (Hazer et al, 2018).

The remainder of this paper will be divided into the following sections. First, greenspace will be defined in the context of these studies while also further exploring access and quality. Second, the link to greenspace and public health will be examined to explore the pathways through which greenspace is posited to affect health outcomes. Third, the historical legacy of Baltimore's structural racism will be discussed to understand how it relates to greenspace equity. Fourth, the policy implications of understanding the greenspace-health link will be considered. Fifth, a spatial analysis will be described and performed to investigate the relationship between greenspace and health outcomes in Baltimore City. Finally, results will be discussed and analyzed.

What is greenspace?

Any study involving greenspace must define what greenspace means. As Taylor & Hochuli (2017) describe, the literature contains a variety of definitions that delimit what a greenspace actually describes. Therefore, researchers are required to appropriately define greenspace within the context of their study in order for broad understandings to be possible. For example, a greenspace might be defined based on the types of vegetation present (trees vs. grass), or it could be defined in terms of the type of space (garden vs. empty lot). For the purpose of this paper, greenspace is defined as any public park space or community managed open space. Baltimore City is home to a number of public parks maintained by Baltimore City's Recreation & Parks Department, but also contains a myriad of smaller community managed open spaces maintained by community groups. The City of Baltimore defines community managed open spaces as follows: "Vacant lots maintained by a community, nonprofit, or more than one household used for vegetable gardens, orchards, pocket parks, and small recreational spaces" (Baltimore Department of Planning, Office of Sustainability, 2018).

The reason for this selection of spaces as greenspaces is for two reasons. First, both of these greenspaces are open to the public thereby presumably providing free benefits to whomever wishes to reap them. Second, these spaces are *managed* and while not necessarily managed at the highest quality level, managed nonetheless. For this reason, we can presume that the quality of these spaces is greater than the average grass lot or tree/plant-filled right away. Quality is noted here as many greenspace-health studies have focused on the quantity of greenspace as opposed to the quality, although literature reviews have noted the need to consider quality in these types of studies (Markevych et al, 2017; Van Den Beg et al, 2015). A simple example can be thought of to prove the need for this point. An empty grass lot does not provide the same benefits as a properly maintained park with various amenities or a community garden that provides food and builds social cohesion. This can be taken even further if we throw trash into the grass lot or crime. Therefore, it is important to consider quality of greenspace rather than just the spaces that contain vegetation as many studies do.

One last point this paper needs to make with regards to defining greenspace is the access that individuals have to these spaces. If there is a benefit to be experienced by these parks or community managed spaces, people must be able to access them to reap the benefit. For this reason, it is important to define a distance within which individuals are likely to walk to a given space. Some studies believe a half mile is the appropriate distance that an individual will walk to a destination (Harnik, P. & Martin, A., 2012) while others note that large variations occur depending on the type of trip being taken (Yong, Y. & Diez-Roux, 2013). Despite this ambiguity, the use of a quarter-mile distance has long been accepted (Atash, 1994) and is best used as a measure of accessibility for this paper. However, it is important to acknowledge that this definition of access is merely an assumption. Just because an individual is within a defined buffer of a greenspace does not mean that the individual actually has access to the greenspace. Other barriers such as roads, dangerous areas or an individual's own physical impairment could restrict them from actually accessing a specific greenspace.

The Greenspace-Health Link

As discussed already, there is general consensus that greenspace promotes improved mental and physical health in urban settings (Van Den Beg et al, 2015). These benefits are believed to result from a number of distinct pathways, with some studies identifying as many as 21 (Kuo, 2015), but are not definitively proven. Markevych et al do a fair job of categorizing the posited pathways thru which greenspace promotes improved human health, which should be briefly reviewed for this paper (2017). They are: 1) Reducing Harm (Mitigation) 2) Restoring Capacities (Restoration) 3) Building Capacities (Instoration).

For reducing harm, greenspaces act as buffers that reduce human exposure to environmental pollutants. For example, trees and certain vegetation in greenspaces can filter the air thereby improving its quality. As a result, humans breathe in less particulate matter or gaseous compounds like ozone that are harmful to health (Hartig et al, 2014). However, these reduction mechanisms are dependent on a host of other factors, such as species or age of vegetation. Even some plants/trees disperse pollen that can have negative effects on human health, thus complicating the mitigation potential. Markevych et al describe a number of other examples such as reducing heat and noise pollution exposure (2017). Heat reduction leads to lower heat-related illness (i.e. heat stroke).

Restoration mechanisms predominantly affect the mental well-being of individuals as it relates to stress. Hartig et al describe the benefits that greenspace provides from removing individuals from the stress and unsightly concrete of the city, and also by providing pleasant views of nature (2014). This reduction in stress has numerous health benefits as stress has been noted to contribute to cause of disease and increased risky behavior (Hazer, 2018). Furthermore, prolonged exposure to stressful environments can weaken the immune system’s functionality (Cohen, 2007).

Capacity building through greenspace is accomplished by providing the environment where resources, knowledge or skills can be exchanged and improved. For example, Kuo describes the importance of greenspaces as sites of building social cohesion and promoting physical activity (2015). Both of these can contribute to improved health. An open park provides an area to perform physical activity such as running or walking, a boon for physical health. Furthermore, greenspaces are often sites of community building and organizing thus allowing for social relationships to be built and maintained. These relationships can promote general mental well-being and also allows residents to look out for one another.

Despite the lack of definitive proof and the many complications that could affect each pathway, there is sufficient general consensus that greenspace promotes better human health. However, this is not the main question of this paper. The focus herein is to understand the Baltimore City specific greenspace-health relationship as this has important local policy implications.

Structural Racism in Urban Areas

Probably the most salient example of structural racism, redlining, has created a massive legacy of inequity across U.S. urban areas. Baltimore experienced this federal government sanctioned discrimination that designated non-white communities as "risky" for mortgage lending (Rothstein, 2017), subsequently followed by a host of other racist exercises like differential tax practices and housing covenants that contributed to the oppression of these neighborhoods. As a result, these communities have struggled at least since redlining began with the Home Owner's Loan Corporation in 1937 to accumulate, maintain or create wealth as well as maintain healthy communities (Williams & Collins, 2016).

One such result of this struggle has been the unequal distribution of greenspace. For example, literature has explored the unequal funding and distribution of parks for people of color as compared to Whites (Byrne & Wolch, 2009). As such, many studies have revealed how this unequal distribution contributes to further inequity in the appropriateness of greenspaces for certain populations based on social class, race, or density (Boulton et al, 2018; Loughran, 2014). For example, a small park may have been built in a residentially dense area, thus providing inadequate space for the potential park users. Additionally, a park in a predominantly Hispanic neighborhood may have been designed to conform to Anglo-normative ideas of nature/recreation revealed in park design, facilities or signage (Byrne & Wolch, 2009), thereby discouraging the majority Hispanic population from using the space in line with their own cultural values of nature/recreation. These insights highlight the need to consider structural forms of racism when studying the relationship between greenspace and health due to their influence on greenspace access. If users are not truly accessing parks, benefits may not be actually realized.

Policy Implications

Understanding the relationship between greenspace and public health has important policy implications that should be explored if our cities are to responsibly use funds to create an environment where all residents can thrive. With regards to Baltimore specifically, it should be noted that the city has recently adopted a comprehensive vision for demolishing vacant homes to develop a network of greenspaces. As the Baltimore City Director of Planning describes in his foreword to the *Green Network Plan*:

> "Recognizing the proven connection between green space and improved public health outcomes, the Green Network will link Baltimore residents to open spaces designed to

> foster community, encourage movement, and reduce external stressors. Transforming vacant lots and buildings into green spaces will also be an economic driver for Baltimore, creating opportunities for new development in areas overlooked for far too long." (Baltimore Department of Planning, Office of Sustainability, 2018)

City planning further recognizes the neighborhood disparities experienced by Baltimore, diverting from a "business as usual" plan that builds from strength rather than scratch. As such, they develop a set of tools to identify prioritization zones where work should begin. However, if a greater understanding of the health-greenspace link was achieved before, these prioritization zones and pilot projects might be modified. Perhaps a given community would not benefit as greatly from an additional greenspace as compared to implementing some other socioeconomic investment (i.e. workforce development).

Regardless, the Planning Department's stance highlights the importance of defining the greenspace-health relationship to inform policy that builds thriving cities. This also presents the opportunity to reiterate the need for city-specific studies due to their unique history of development. Baltimore City's history of structural racism is different from that of Detroit's. Even if common themes like redlining exist, different geographies and other socioeconomic, demographic, and historical factors exist that may differentially impact their city's greenspace-health relationship.

Data

In order to explore the relationship between public health outcomes and managed greenspace in Baltimore City, there is a wealth of secondary data to make use of in a GIS study.

First, greenspace data exists in both raster and vector format. Baltimore City Recreation & Parks maintains a polygon dataset of all parks within city limits. The Baltimore Neighborhood Indicators Alliance (BNIA) – Jacob France Institute also maintains a point dataset of all Community Managed Open Spaces (CMOS) in Baltimore City. In combination with the public available Baltimore Real Property Database, polygons are available for all managed greenspaces in Baltimore City.

The above datasets merely delineate the boundaries of these greenspaces, but do not actually measure the amount of green vegetation they hold. For this reason, Chesapeake Conservancy's high resolution (1 meter) land cover database is helpful. This dataset is collected for the entire Chesapeake Bay watershed, categorizing natural and manmade features of the landscape. The following categorizations are useful in defining vegetation for this paper: Water, Tree Canopy, Shrub Scrub, Low Vegetation, Tree Canopy over Structures, Tree Canopy over Impervious Surfaces, and Tree Canopy over Roads. A full description of these classifications can be found in the Chesapeake Conservancy's Baltimore City Land Cover metadata (2016).

Census Tract Maps and associated demographic data are publicly available from the U.S. Census TIGER/Line Shapefile geodatabases. Socioeconomic data is available in the form of an area deprivation index (ADI) developed by a research group at the University of Wisconsin's Department of Medicine (Kind, 2013) following the methodology of Singh (2003) to rank "neighborhoods by socioeconomic status disadvantage." This methodology uses 17 Census variables related to "theoretical domains of income, education, employment, and housing quality" to perform rankings at either a State or National level. This data is provided at the Census Tract – Block Group level. Historical redlining data is available from a multi-university collaborative project, “Mapping Inequality – Redlining in New Deal America”, where Home Owner’s Loan Corporation Residential Security Risk (redline) maps have been digitized into polygons of the four classes of risk.

The last piece necessary for this paper is health data, which is conveniently available from the 500 Cities Project. This project was a collaboration between the Centers for Disease Control & Prevention (CDC) and the Robert Wood Johnson Foundation to geospatially present various health outcomes for the 500 largest U.S. cities at the Census Tract level (2017). The two variables of interest are “Mental health not good for≥14 days among adults aged≥18 years” and “Physical health not good for≥14 days among adults aged≥18 years.” These are a measure of the number of respondents older than 18 who have reported 14 or more days during the past 30 days where their mental (or physical) health was not good. This data was collected from the CDC’s Behavioral Risk Factor Surveillance System (BRFSS) phone survey, which means that this measure is a subjective, self-reporting. Therefore, there is limitation to this measure as there is no definitive measure of what is a “bad day” of mental and/or physical health, and any definition is subjective to the individual asked.

Table 1: All data is for the Baltimore City area.

Data	**Year**	**Source**	**Format**
Parks	2018	Baltimore City Recreation & Parks Department	Polygons
Community Managed Open Spaces (CMOS)	2013	Baltimore Neighborhood Indicators Alliance – Jacob France Institute	Points
Real Property Database	2019	City of Baltimore Open GIS Data Site	Polygons
Land Cover Classification (1 meter resolution)	2016	Chesapeake Conservancy	Raster
Area Deprivation Index (ADI) [Block Group]	2013	University of Wisconsin – Department of Medicine	Polygon

Median Age; Race; Gender [Census Tract]	2016	US Census Bureau TIGER/Shapefile Geodatabase	Polygon
Physical & Mental Health [Census Tract]	2017	Centers for Disease Control & Prevention (CDC)	Polygon
Home Owner's Loan Corporation Residential Security Map	1937	Mapping Inequality – Redlining in New Deal America	Polygon
Crime Data	2018	City of Baltimore's Open Data Catalog	Points

Methods

The outcome of this paper's methods are multiple spatial regressions in GeoDa software using the previous data as described in Table 1 at the Census Tract level to look at the relationship between *managed* (quality) greenspace and physical and mental health respectively. However, before this was done, QGIS 3.4.4 was used to prepare spatial data for the regression models. To perform this work, all datasets were initially re-projected into EPSG 102685: NAD_83_StatePlane_Maryland_FIPS_1900_Feet projection for conformity. Some data cleaning was necessary in order to operationalize all datasets.

First, an area weighted calculation was used to convert the ADI Block Group data to a value at the Census Tract level. Each block group area was measured and set against its enveloping census tract to determine its proportion of that the tract's total area. This was then used to calculate a portion of the total tract ADI value. After repeating for all block groups, values were summed by their respective tracts to determine an ADI tract value. This calculation was performed in Microsoft Excel using pivot tables.

Redlining data was evaluated by overlaying the "highest risk" or "redlined" polygons over census tracts. Tracts that were observed to be at least half covered by the redline polygon were considered redlined, and assigned a value of "1" for a newly created redline variable. Crime data was filtered for only 2018 crimes since the dataset is consistently updated every day. A "count points in polygon" function was used to determine the number of crimes within each census tract.

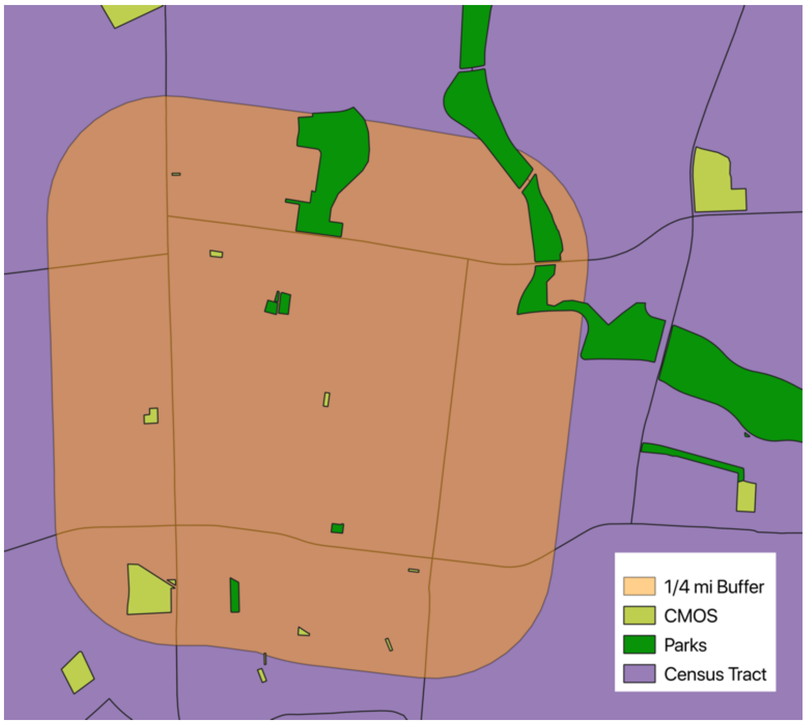

Figure 1: Each tract is buffered for ¼ mile to determine access to nearby greenspace. The sum of these parks and community managed open spaces (CMOS) will quantify a tract's greenspace.

Calculations for greenspace area were a bit more complicated. In order to obtain polygons of CMOSs, a spatial join was performed to match each CMOS point to its respective plot. Now with both polygon shapefiles of the two *managed* public greenspaces (parks and CMOSs), the actual square footage of greenspace could be calculated using land cover data. Therefore, zonal statistics were performed to count the number of green/vegetation pixels within each greenspace. This number was multiplied by the square footage of one pixel (~10.688 ft^2) to calculate the total greenspace square footage. After calculating this square footage of green for each space, it was necessary to determine a total "accessible" value for each census tract. As mentioned previously, access is being defined as a quarter mile around each tract boundary due to the long-accepted standard pedestrian walking distance (Atash, 1994). Therefore, a quarter mile buffer was created for each census tract to determine which greenspaces would be "within reach" of a given census tract (See Figure 1). To calculate the actual value of square footage, managed greenspaces (parks and CMOSs) were spatially joined with the intersect function to census tract buffers to summarize the total green square footage of the managed greenspaces for each tract. This simultaneously counted the number of greenspaces a tract had "access" to.

Results

After calculating the greenspace square footage and adjusting the ADI, all data was at the census tract level and ready for use in regression models with GeoDa 1.12.1.161. Models that were run are listed in Tables 2 - 5. Statistics are presented to assess goodness-of-fit for each model where higher log likelihood (LIK) and lower Akaike Information Criterion (AIC) indicate a better fit (Matthews, 2006). Model 1 examined the number of individuals reporting increased occurrence of "bad" physical health days for a given month as it relates total accessible square footage of greenspace, while also controlling for sex, age, race, crime, socioeconomics, and redlining. Population of each track was considered for sex, race and crime. For example, each unit increase in crimes means one more crime per person in a given census tract. The same model was run using mental health instead of physical health as Model 2. Each of these models were then replicated, but by replacing square feet of managed greenspace with the total number of "accessible" greenspaces against each health indicator (Models 3 & 4).

Table 2: Model 1 - Physical Health & Managed Greenspace Square Footage

Variable	Run 1	Run 2	Run 3
Men	229.99		
Women	234.572		
White	1.82852		
Black	5.99464		
American Indian	27.2067		
Asian	-5.49667		
Native Hawaiian/Pacific Islander	**-195.906 ** **	**-249.553 ** **	**-248.837 ** **
Hispanic	**7.76327 * **	-0.92493	
ADI State	**0.421704 ** **	**0.754022 ** **	**0.750606 ** **
Crime	21.6768		
Redlined	0.4742		
Square Feet of Managed Greenspace	-1.29199e-08		
Age	0.0413604		
R^2	0.783041	0.712710	0.712785
LIK	-407.835	-440.439	-440.519
AIC	845.669	890.879	889.039

** = p < 0.05, ** = p <0.01, ***= p <0.001*

Table 3: Model 2 - Mental Health & Managed Greenspace Square Footage

Variable	Run 1	Run 2	Run 3
Men	150.39		
Women	152.256		
White	0.65601		
Black	3.93402		
American Indian	27.7381		
Asian	-3.01403		
Native Hawaiian/Pacific Islander	**-127.999** **	**-156.01** **	**-156.561** **
Hispanic	**6.41893* **	0.521703	
ADI State	**0.366089*** **	**0.633132*** **	**0.633485*** **
Crime	15.0104		
Redlined	0.283225		
Square Feet of Managed Greenspace	-1.26638e-08		
Age	**-0.101185*** **	**-0.095008*** **	**-0.0961493*** **
R^2	0.782724	0.727460	0.727327
LIK	-364.597	-390.853	-390.893
AIC	759.195	793.706	791.786

** = p < 0.05, ** = p <0.01, ***= p <0.001*

Table 4: Model 3 - Physical Health & Number of Managed Greenspaces

Variable	**Run 1**	**Run 2**	**Run 3**
Men	214.205		
Women	218.801		
White	2.11184		
Black	6.1915		
American Indian	28.5948		
Asian	-4.92076		
Native Hawaiian/Pacific Islander	**-196.666****	**-249.553*****	**-248.837*****
Hispanic	**8.44406****	-0.92493	
ADI State	**0.430548*****	**0.754022*****	**0.750606*****
Crime	19.6072		
Redlined	0.353769		
Number of Managed Greenspaces	0.00739031		
Age	0.0401901		
R^2	0.781916	0.712710	0.712785
LIK	-407.864	-440.439	-440.519
AIC	845.729	890.879	889.039

** = p < 0.05, ** = p <0.01, ***= p <0.001*

Table 5: Model 4 - Mental Health & Number of Managed Greenspaces

Variable	**Run 1**	**Run 2**	**Run 3**
Men	135.435		
Women	137.304		
White	0.815359		
Black	3.96393		
American Indian	28.7126		
Asian	-2.42888		
Native Hawaiian/Pacific Islander	**-134.712****	**-156.01****	**-156.561****
Hispanic	**6.82454***	0.521703	
ADI State	**0.372982*****	**0.633132*****	**0.633485*****
Crime	13.8525		
Redlined	0.263863		
Number of Managed Greenspaces	0.00439997		
Age	**-0.102907*****	**-0.095008*****	**-0.0961493*****
R^2	0.780600	0.727460	0.727327
LIK	-365.336	-390.853	-390.893
AIC	760.672	793.706	791.786

** = p < 0.05, ** = p <0.01, ***= p <0.001*

All models resulted in similar findings, with greenspace (as a total accessible square footage or number of accessible spaces) not having any significant correlation to reported physical or mental health. This is contradictory to expected findings, and other studies that have found positive associations. On the physical health side, for both square feet of managed greenspace (Model 1) and number of managed greenspaces (Model 3), the only significant factors affecting self-reported physical health were the area deprivation index (ADI) and the Native Hawaiian and Other Pacific Islander population. The same results were identified with the mental health models (2 & 4) but with the addition of age as also being a significant factor in determining mental health outcome. It is also noted that testing for multicollinearity in GeoDa using a classic OLS model revealed high multicollinearity among race and sex variables. However, because these are not variables of interest, we can ignore those collinear relationships.

Discussion

While the results of this study do not align with what was expected, this provides insight as reviews show that not all greenspace-health studies illuminate significant correlations (Van den Berg et al, 2015). Each of the four model runs reveals other factors that have a greater effect on health as compared to greenspaces. For example, in Model 1 & 2 when looking at the relationship between physical health and greenspace (in terms of total managed square footage and number of "accessible" spaces) we find that greenspace does not demonstrate a significant correlation. Instead, only Native Hawaiian and Pacific Islander race and the Area Deprivation Index (ADI) show significant correlations. With regards to the Native Hawaiian and Pacific Islanders, this particular result can be thought of as an anomaly with no actual relevance. First, the proposed effect does not make sense with this study's metric for measuring physical health.

This metric measures the number of people that report a minimum number of days of bad physical health for a given month with an average value of about 13 people in a given tract. With the proposed effect, a census tract with a one unit increase in this racial group (a homogenous Native Hawaiian Pacific Islander population) would have essentially perfect physical health due to the large reduction in number of people reporting poor physical health. (Race is represented as a proportion to account for population variances among tracts.) Additionally, the data used from the Census indicates the population of Native Hawaiian and Pacific Islanders in Baltimore City is only 342 individuals further highlighting this outlier.

What is really noteworthy from these two models is the significant effect that ADI has on physical health. We see a significant increase in reported poor physical health as ADI increases (lower socioeconomic status). This effect persisted despite all other controlled factors such as crime, race, gender, age, and redlining. ADI involves a number of indicators such as income, employment, homeownership and educational attainment. Therefore, it is reasonable to assume that these many socioeconomic factors have influence on physical health outcomes. Perhaps an individual with lower educational achievement and income lacks the financial ability to visit a doctor when ill or free time to exercise. While previous work has discussed pathways through which greenspace can provide space for physical activity (Kuo, 2015; Markevych et al, 2017), that does not mean that people actually have the time (or access) to do so. Furthermore, these socioeconomic factors may contribute greater negative health outcomes as compared to positive ones that greenspaces provide.

Remaining Models 3 & 4 that explore the relationship between mental health and greenspace (as total managed square footage and number of “accessible” greenspaces) present findings similar to those just discussed. In both models, greenspace is not statistically relevant. Instead ADI and Native Hawaiian Pacific Islander persist with the addition of age. Identical arguments can be presented for ADI and Native Hawaiian Pacific Islander, and so these will not be repeated. The only clarification to make is that the socioeconomic factors that may contribute to poor physical health can lead to poor mental health outcomes as well. For example, individuals struggling with home ownership or insufficient income may experience emotional distress due to fear of being able to provide for themselves and their families.

Models 3 & 4 also report a negative association between increased age and poor mental health. There could be a couple of reasons for this relationship. First, mental health issues may be underreported by individuals due to fear of stigma or misdiagnoses with other age-related illness as described by the World Health Organization (2017). As a reminder, the health data in this study is a self-reported survey, the BRFSS. Second, older populations may be in a better emotional state of life due to experience and/or security in their profession (or retirement). A Centers for Disease Control & Prevention report on the State of Mental Health and Aging in America reveals that less than 10% of individuals 50 and older in the BRFSS from 2006 reported greater than 14 days of mental distress in a 30-day period (2008). While this may not completely explain this study’s identified association, it may have some contributory role.

These results should caution planners who think a blanket approach to developing greenspace will address health inequalities/disparities. There is established literature that describes the strong link between social environments, poverty and other structural factors and poor public health (Geronimus, 2000; Corburn, 2004). Therefore, it should be important to remember these critical issues that can be addressed to realize improved health outcomes rather than hedging our bets on greenspace planning. As my advisor notes, to improve disadvantaged neighborhoods we cannot just plant trees. If we do plant trees, we should simultaneously invest in the people of these communities.

Additionally, parks are not just green *spaces*, they are green *places* due to their inherent social value and construction. Different cultures experience, value and use parks and greenspaces differently (Devier, n.d.; Gentin, 2011; Ordóñez-Barona, 2017). Therefore, a park that offers ample aesthetic viewing opportunities will not equally benefit all peoples. It is important to reiterate the need for community-oriented planning in greenspaces that are still being built while also considering poverty and race (Geronimus, 2000).

Conclusion

While current literature has enjoyed the consensus that greenspace may be able to provide remedies to environmental, social and economic problems in urban areas (U.S. Department of Agriculture Forest Service, 2018; Van den Berg et al, 2015), this study implores us to pause before going "all in." There are difficulties in proving these links decisively due to a host of other confounding factors and multiple pathways through which greenspace benefits might actually act (Markyvech et al, 2017). These predominantly include socioeconomic factors such as income, education, homeownership, all of which have potential to influence an individual's health (Corburn, 2004). As described in this paper, I find no significant relationship between managed greenspace (in terms of square footage and number of managed spaces) and physical or mental health outcomes at the Census Tract level in Baltimore City using spatial regression. Furthermore, this lack of association is accompanied by a consideration of an important historical, structural factor (redlining) as well as an attempt to incorporate quality of greenspace. Quantity of greenspace has often been favored over quality of greenspace in these types of studies, while redlining has never been considered to this author's knowledge.

Despite this paper's claim to find no significant benefit of managed greenspace for resident health in Baltimore City, this author does not wish to discredit greenspace benefits. This paper should serve as a call to pursue further research into Baltimore City's greenspace landscape and public health while also engaging city planners and residents. In doing so, greenspace and sustainability planning, like Baltimore's *Green Network Plan*, can be implemented in a responsible and effective manner. Cities are unique, therefore, we should be careful to understand that urban greenspace polices must be tailored to their specific city. Perhaps approaches to address historical and present day socioeconomic factors may be our best bet for improving public health rather than a focus on more greenspace.

References:

Anguluri, R., & Narayanan, P. (2017). Role of green space in urban planning: Outlook towards smart cities. *Urban Forestry and Urban Greening*, *25*(March 2016), 58–65. https://doi.org/10.1016/j.ufug.2017.04.007

Atash, F. (1994). Redesigning suburbia for walking and transit: emerging concepts. *Journal of Urban Planning and Development*, *120*(1), 48-57.

Baltimore City. (n.d.). Crime | Open Baltimore | City of Baltimore's Open Data Catalog. Retrieved May 1, 2019, from https://data.baltimorecity.gov/Crime/crime/rp9g-42r9

Baltimore City. (2019, January 4). Real Property. Retrieved from http://gis-baltimore.opendata.arcgis.com/datasets/b41551f53345445fa05b554cd77b3732_0

Baltimore Department of Planning, Office of Sustainability. (2015). *Green pattern book: using vacant land to create greener neighborhoods in Baltimore.*

Baltimore Department of Planning, Office of Sustainability. (2018). *Green Network Plan*.

BNIA-JFI. (2013). Baltimore's Green Registry. Retrieved May 1, 2019, from http://water.bniajfi.org/

Boulton, C., Dedekorkut-Howes, A., & Byrne, J. (2018). Factors shaping urban greenspace provision: A systematic review of the literature. *Landscape and Urban Planning*, *178*(May), 82–101. https://doi.org/10.1016/j.landurbplan.2018.05.029

Byrne, J., & Wolch, J. (2009). Nature, race, and parks: Past research and future directions for geographic research. *Progress in Human Geography*, *33*(6), 743–765. https://doi.org/10.1177/0309132509103156

Centers for Disease Control & Prevention. (2017, November 28). 500 Cities: Local Data for Better Health. Retrieved from https://www.cdc.gov/500cities/index.htm

Centers for Disease Control and Prevention and National Association of Chronic Disease Directors. (2008). *The State of Mental Health and Aging in America Issue Brief 1: What Do the Data Tell Us?* (Issue brief).

Chesapeake Conservancy. (2016). High-Resolution Data. Retrieved May 1, 2019, from https://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *Jama*, *298*(14), 1685-1687.

Corburn, J. (2004). Confronting the challenges in reconnecting urban planning and public health. *American journal of public health*, *94*(4), 541-546.

Devier, Garrett. (n.d.). Cultural and Ethnic Minority Use of Open Space. http://depts.washington.edu/open2100/Resources/5_New%20Research/

Gentin, S. (2011). Outdoor recreation and ethnicity in Europe-A review. *Urban Forestry and Urban Greening*, *10*(3), 153–161. https://doi.org/10.1016/j.ufug.2011.05.002

Geronimus, A. T. (2000). To mitigate, resist, or undo: addressing structural influences on the health of urban populations. *American journal of public health*, *90*(6), 867.

Harnik, P., & Martin, A. (2012). *Close-to-Home Parks: A Half-Mile or Less*.

Hazer, M., Formica, M. K., Dieterlen, S., & Morley, C. P. (2018). The relationship between self-reported exposure to greenspace and human stress in Baltimore, MD. *Landscape and Urban Planning*, *169*(August 2017), 47–56. https://doi.org/10.1016/j.landurbplan.2017.08.006

Kind, A. (2013). Neighborhood Atlas. Retrieved May 1, 2019, from https://www.neighborhoodatlas.medicine.wisc.edu/

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, *6*(August), 1–8. https://doi.org/10.3389/fpsyg.2015.01093

Loughran, K. (2014). Parks for profit: The high line, growth machines, and the uneven development of urban public spaces. *City & Community*, *13*(1), 49-68.

Matthews, S. A. (2006.). *GeoDa and Spatial Regression Modeling*. Lecture presented at GISPopSci Workshop Penn State 2006. Retrieved from ibis.geog.ubc.ca/~brian/workshop/GeoDa_Spatial_Regression.pdf

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., … Fuertes, E. (2017). Exploring pathways linking greenspace to health : Theoretical and methodological guidance. *Environmental Research*, *158*(June), 301–317. https://doi.org/10.1016/j.envres.2017.06.028

Nelson, R. K., Winling, L., Marciano, R., Connolly, N., et al. (n.d.), “Mapping Inequality,” *American Panorama*, ed. Robert K. Nelson and Edward L. Ayers, accessed May 1, 2019, https://dsl.richmond.edu/panorama/redlining/#loc=11/39.2647/-76.6447&opacity=0.8&city=baltimore-md.

Ordóñez-Barona, C. (2017). How different ethno-cultural groups value urban forests and its implications for managing urban nature in a multicultural landscape: A systematic review of the literature. *Urban Forestry and Urban Greening*, *26*(October 2016), 65–77. https://doi.org/10.1016/j.ufug.2017.06.006

Rothstein, R. (2017). *The color of law: A forgotten history of how our government segregated America*. Liveright Publishing.

Singh, G. K. (2003). Area deprivation and widening inequalities in US mortality, 1969–1998. *American journal of public health*, *93*(7), 1137-1143.

Taylor, L., & Hochuli, D. F. (2017). Defining greenspace: Multiple uses across multiple disciplines. *Landscape and Urban Planning*, *158*, 25–38. https://doi.org/10.1016/j.landurbplan.2016.09.024

US Census Bureau. (2016). TIGER/Line with Selected Demographic and Economic Data. Retrieved from https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-data.html

U.S. Department of Agriculture Forest Service (2018). Urban Nature for Human Health and Well-Being, 24. Retrieved from https://www.fs.fed.us/sites/default/files/fs_media/fs_document/urbannatureforhumanhealthandwellbeing_508_01_30_18.pdf

Van Den Berg, M., Wendel-vos, W., Poppel, M. Van, Kemper, H., Mechelen, W. Van, & Maas, J. (2015). Urban Forestry & Urban Greening Health benefits of green spaces in the living environment : A systematic review of epidemiological studies. *Urban Forestry & Urban Greening*, *14*(4), 806–816. https://doi.org/10.1016/j.ufug.2015.07.008

Williams, D. R., & Collins, C. (2016). Racial residential segregation: a fundamental cause of racial disparities in health. *Public health reports*.

World Health Organization. (2017, December 12). Mental health of older adults. Retrieved from https://www.who.int/news-room/fact-sheets/detail/mental-health-of-older-adults

Yong, Y., & Diez-Roux, A. V. (2013). Walking Distance by Trip Purpose and Population Subgroups Yong. *Am J Prev Med*, *43*(1), 11–19. https://doi.org/10.1016/j.amepre.2012.03.015.Walking