GREATER ACCESS TO RECREATIONAL RESOURCES IS ASSOCIATED WITH MORE LEISURE-TIME PHYSICAL ACTIVITY ENGAGEMENT IN COUNTIES ACROSS THE UNITED STATES

by

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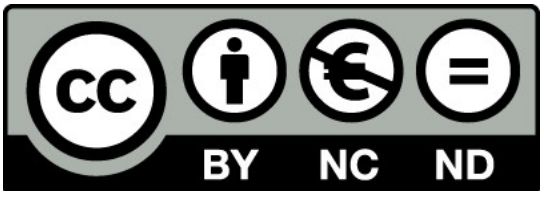

DISSERTATION ABSTRACT

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Title: Greater Access to Recreational Resources is Associated with More Leisure-time Physical Activity Engagement in Counties Across the United States

Less than 10% of U.S. adults meet physical activity recommendations. Physical inactivity leads to poor physical and mental health conditions. Little is known about community factors on a county level associated with leisure-time physical activity (LTPA), despite LTPA demonstrating greater health benefits than other physical activity domains and most local health departments operating on county levels. This study: 1) examines the association between access to recreational resources and LTPA, and 2) investigates violent crime rates as a moderator of this association across U.S. counties. Data on access to recreational resources (e.g., parks, gyms), LTPA, violent crime rates, median household income, and percent rurality, Black/African American population, and Latina/o population were analyzed from 2016 County Health Rankings and Roadmaps and American Community Survey. With U.S. counties ($N = 3089$) as the level of measurement, three spatial regression models stratified by region (Northeast, South, West, Midwest) were conducted. Access to recreational resources was positively associated with LTPA in the Northeast ($b = 0.058$, $p = .001$), South ($b = 0.025$, $p < .001$), and West ($b = 0.046$, $p < .001$). Violent crime rates moderated the association between access to recreational resources and LTPA in the Northeast only ($b = 0.002$, $p = .032$), showing a significant positive association ($b = 0.108$, $p < .001$) only among counties with

higher violent crime rates. Exploratory findings indicated median household income moderated the association between access to recreational resources and LTPA in the West (b = 0.002, p = .003) and Midwest (b = 0.001, p = .040). County median household income may matter more as a moderator than violent crime rates in the positive association between access to recreational resources and LTPA, particularly in the West and Midwest. These findings can inform future LTPA promotion interventions by concentrating efforts on improving access to recreational resources and addressing inequities in access based on median household income.

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CHAPTER I

INTRODUCTION

The 2nd edition of the Physical Activity Guidelines for Americans (Piercy et al., 2018) recommends that adults should be engaging in approximately 150 minutes to 300 minutes of at least moderate-intensity physical activity a week. However, less than 10% of adults in the United States (U.S.) are meeting these recommended amounts of physical activity (Troiano et al., 2008). Adults (20-59 years old) and older adults (60+ years old) were shown to be the least active with 95.5% and 97.6% of these age groups not meeting the recommend amounts of physical activity respectively (Troiano et al., 2008). Along with age differences in physical activity engagement, differences in moderate-intensity physical activity have been seen between racial/ethnic groups. Latina/o (12.3%) and Black/African American (12.5%) adults have been found to be significantly less likely to meet recommendations for moderate-intensity physical activity compared to non-Latina/o White adults (16%; Carlson et al., 2010), although the percent of non-Latina/o White adults meeting these recommendations is low as well.

The lack of adults meeting physical activity recommendations is a concern as physical inactivity is a prominent risk factor for chronic health conditions and diseases like hypertension, heart disease, cardiovascular disease, type 2 diabetes, and several types of cancer (Knight, 2012; Piercy et al., 2018). These conditions are leading causes of death in the United States (Roth et al., 2017). Past literature has characterized physical inactivity as a pandemic because of its prevalence and direct link to higher mortality in the United States (Carlson et al., 2018; Mokdad et al., 2004) and worldwide (Kohl et al., 2012). In addition to the impact that physical inactivity has on community health, it also

has been found to be a risk factor for poor mental health (Loprinzi, Franz, & Hager, 2013; Mason & Kearns, 2013) and for accelerated onset of dementia in older populations (Knight, 2012). However, more physical activity engagement has been linked to lower odds of depressive symptoms and anxiety (Reiner et al., 2013).

With most of the physical activity literature focusing on overall physical activity, less is known about the potential positive impact that different domain-specific physical activities have on health outcomes (Samitz et al., 2011). The four main domains of physical activity are occupational, domestic, transportation, and leisure-time physical activity (LTPA; Strath et al., 2013). Occupational physical activity is defined as work-related tasks that involve manual labor (e.g., carrying or lifting objects). Domestic physical activity includes housework and yard work, chores, and childcare. Transportation physical activity is traveling from one location (e.g., store, work, or school) to another by an active means, such as walking or bicycling (Strath et al., 2013). Lastly, LTPA is any physical activity that individuals engage in during their disposable time (Steinbach & Graf, 2008). One study by Samitz et al. (2011), found that the domains of physical activity had differing impacts on all-cause mortality. For instance, stronger effects were found between more LTPA and reduced mortality compared to the effects of greater occupational and transportation activities with reductions in mortality. Another study found that low LTPA engagement, regardless of occupational physical activity engagement, was associated with higher mortality rates in adults (Clays et al. 2013). Clays et al. (2013) posited that higher occupational physical activity and lower LTPA are associated with higher mortality because, unlike LTPA, occupational physical activity does not allow for autonomy related to the frequency, duration, or intensity of the

physical activity. LTPA is characterized by autonomy, motivation, control, and intention to drive the frequency, duration, and intensity of engagement. This explanation is aligned with The Theory of Planned Behavior that indicates that an autonomy bolsters intrinsic motivation to engage in an activity and enjoyment of the activity (Hagger et al., 2003), which ultimately lead to improvements in overall health (Seifert et al., 2012). With theoretical groundings and evidence indicating the stronger health benefits of LTPA compared to domestic and occupational physical activity (Samitz et al., 2011), it is important to study LTPA engagement separately from the other physical activity domains (Holtermann et al., 2018). Specifically, more research is needed to identify community-level factors that are associated with LTPA engagement rather than examine the domains combined as overall physical activity (Gabriel, Morrow, & Woolsey, 2012). Identifying these community-level factors associated with LTPA could inform interventions that aim to promote LTPA on a community level (Bopp & Fallon, 2008, Roux et al., 2008). Making changes to communities' environments has been shown to be the most cost-effective approach (Laine et al., 2014) while having the greatest potential to create community-level change in physical activity and other health behaviors (Matson-Koffman et al., 2005).

Several frameworks can guide an investigation of community-level factors associated with LTPA engagement. For example, ecological frameworks (Bauman et al., 2012) and equity frameworks (Humphreys & Ogilvie, 2013; O'Neill et al., 2014) outline that community-level factors can be characterized as either physical or social in nature. These frameworks posit that both physical and social community-level factors influence health behaviors, like LTPA, independently (Foster et al., 2014; Gomez et al., 2004;

Kaczynski & Henderson, 2007; Kaczynski et al., 2014; Cerin et al., 2018; Schipperijn et al., 2017) or through interactions with each other (Bracy et al., 2014; Perez et al., 2016; Sugiyama et al., 2013; Van Cauwenberg et al., 2017). Guided by these frameworks, physical and social community-level factors and their potential interactions with each other and LTPA are discussed next.

Regarding overall physical activity as well LTPA, access to recreational resources has been identified in the literature as a supportive physical community-level factor. Greater access to recreational resources can be defined as having both commercial venues (e.g., gyms, community centers, dance studios) within a mile and free locations that promote physical activity (e.g., parks and trails) within half a mile of an individual's home. Greater access to recreational resources is often associated with more overall physical activity engagement (Kaczynski & Henderson, 2007; Kaczynski et al., 2014; Cerin et al., 2018; Schipperijn et al., 2017). Kaczynski et al. (2014) found that a greater number of parks and greater access to larger park space within a mile radius of one's home were associated with more LTPA engagement. Kaczynski et al. (2014) also found that individuals engaged in more LTPA in community parks that had specific recreational resources (e.g., playgrounds, fitness stations, trails) compared to parks without these resources. In an examination of eight different countries, greater numbers of recreational resources and greater perceived access (within one kilometer of one's home) to recreational resources were associated with more objectively measured LTPA engagement and more moderate-to-vigorous intensity physical activity (Schipperijn et al., 2017).

Access to recreational resources has been operationalized in additional ways than previously specified, which has undoubtedly contributed to mixed findings in regard to its association with overall physical activity and LTPA (Bancroft et al., 2015; Hillsdon et al., 2006). For example, Bancroft et al. (2015) state in their systematic review that when studies only examine density of parks there was no signification association with physical activity. The size and quality of recreational resources has also been found to not correlate with LTPA engagement. Proximity to recreational resources may be the component of access to recreational resources that really matters when it comes to LTPA engagement. For instance, Cerin et al. (2018) found that perceived proximity to recreational resources served as a mediator in the positive association between number of parks and moderate-to-vigorous intensity physical activity engagement. Among the limited extant literature that has examined the association between access to recreational resources, operationalized as proximity to recreational resources, and LTPA, rather than overall physical activity, most of these studies have be conducted on an individual-, neighborhood-, or city-level, or county-level in a single state (Cerin et al., 2018; Huston et al., 2003; Schipperijn et al., 2017). It is unknown whether this association is present in counties across the United States. Studying this association on a county level across the nation, can inform both local health departments' and federal public health agencies' efforts to promote more LTPA engagement and improve public health.

Crime may be another salient social community-level factor related to overall physical activity and access to recreational resources. Some studies have found evidence for crime being inversely associated with overall physical activity and access to recreational resources (Foster et al., 2014; Gomez et al., 2004; Harrison, Gemmell, &

Heller, 2007; Janke, Propper, & Shields, 2016; McGinn et al., 2008; Nehme et al., 2016; Orstad et al., 2017; Rees-Punia, Hathaway, & Gay, 2018; Stodolska, Shinew, & Acevedo, 2013), while others have found that crime is not correlated with physical activity (Da Silva et al., 2016; Foster & Giles-Corti, 2008; Van Cauwenberg et al., 2018). These inconsistent findings are may be due to varying operationalizations of crime (Foster & Giles-Corti, 2008). Most studies measure perceived safety from crime (e.g., likelihood of crime in one's neighborhood, how safe one feels in their neighborhood; Foster & Giles-Corti, 2008), as safety from crime has been found to be correlated with more physical activity (Rees-Punia et al., 2018). Fewer studies have used objective measures of crime and these studies have found higher crime to be associated with reductions in physical activity (Orstad et al., 2017; Rees-Punia et al., 2018). Studies that have used objective measures of crime most often use police-reported crimes in an area (Rees-Punia et al., 2018), although other measures exist like, rating the amount of police attention required within a community (van Lenthe et al., 2005). Regarding objective measures of crime, crime is also most often measured in a global way (i.e., overall crime rates; Foster & Giles-Corti, 2008) rather than examining the factors associated with more specific types of crime, like violent crime rates (e.g., murder, manslaughter, rape, robbery, and aggravated assault; Criminal Justice Information Services Division, 2018) or property crimes (e.g., burglary). Violent crime rates are not often examined, as of Rees-Punia et al.'s (2018) met-analysis, only four studies have examined the direct association between objective measures of crime and physical activity. Violent crime rates have been shown to directly correlate LTPA engagement but in two opposing ways. For instance, greater violent crime rates are associated with both more engagement in LTPA (Foster et al.,

2014) and less LTPA engagement (Gomez et al., 2004). These opposing directions of this association suggests that there may be another relevant factor involved and warranting further investigation.

The role that violent crime rates may play in the association of access to recreational resources and LTPA engagement is unknown. In adjacent literature, four studies have examined globally-measured crime as a moderator of associations between various environmental variables and overall physical activity and show mixed findings (Bracy et al., 2014; Perez et al., 2016; Sugiyama et al., 2014; Van Cauwenberg et al., 2017). Of the four studies, two found that perceived safety from crime moderated the association between built environment characteristics (e.g., street density and connectivity, land use, sidewalk maintenance) and moderate-to-vigorous intensity LTPA engagement (Bracy et al., 2014; Perez et al., 2016). The other two studies tested perceptions of crime as a moderator of access to recreational resources and LTPA engagement, where greater access to recreational resources would be associated with more LTPA engagement in neighborhoods with more favorable social environments (Sugiyama et al., 2014; Van Cauwenberg et al., 2017). Neither of these two studies found perceptions of crime to moderate the association between access to recreational resources and LTPA engagement. Examining violent crime rates as a potential moderator of the association between access to recreational resources and LTPA engagement may assist in elucidating mixed findings and help explain how these social and physical community-level factors interact in their association with LTPA (Van Cauwenberg et al., 2017), especially on a county level across the nation. It is imperative to respond to previous literature by focusing on social environmental factors and examining the role of crime

through different measures in the interaction between access to recreational resources and LTPA engagement (Bracy et al., 2014; Van Cauwenberg et al., 2017).

The covariates included are shown in the literature to have an association with overall physical activity, LTPA engagement, or access to recreational resources and are guided by ecological and equity frameworks (Bauman et al., 2012; Humphreys & Ogilvie, 2013; O'Neill et al., 2014). Racial/ethnic inequities exist in the accessibility of recreational resources, such that Black/African American and Latina/o populations had constraints on access from feeling unwelcome as well as public transportation not being close to the recreational resources (Stanis et al., 2009). This lack of access is problematic for Latina/o and Black/African American populations, as these racial/ethnic groups have been found to engage in significantly less LTPA than non-Latina/o White adults (Kaczynski et al., 2011; Marquez et al., 2010). However, some evidence suggests that when transitioning from adolescence to adulthood, Black/African American females are more likely than White females to maintain greater amounts of physical activity (Gordon-Larsen et al., 2004). Overall, Latina/o and Black/African American populations engage in less physical activity, and have less access to recreational resources than non-Latina/o White populations (Powell et al., 2006). Improvements to the environment, such as having a greater number of appropriate recreational resources have been shown to promote more physical activity engagement. For example, when adolescents have access to recreational resources, like community recreational centers, adolescents show greater odds of engaging in moderate-to-vigorous physical activity (Gordon-Larsen et al., 2004). In adults, Vaughan et al. (2013) found discrepancies in what park amenities are offered based on the racial/ethnic makeup of the area. In census tracts with predominately non-

White residents there were a greater number of parks with basketball courts and fewer parks with trails than in census tracts with predominately White residents. Additionally, other factors like income reveal barriers to LTPA engagement, as lower-income areas have been found to have significantly less recreational resources compared to higher-income areas (Powell et al., 2006; Sugiyama et al., 2015). Those in lower-income communities have also been found to engage in less physical activity when compared to higher-income communities (Gordon-Larsen et al., 2004; Kari et al., 2015). Lastly, overall physical activity levels differ between rural and urban areas. Across the United States, adults in urban areas of the United States engaged in more physical activity than adults in rural areas (Martin et al., 2005). The use of recreational resources, such as parks, also differ between rural and urban areas. A study showed that people visited rural parks more often than urban parks; however, visitors at rural parks engaged in less physical activity (Shores & West, 2010). Given their empirical relevance, these covariates were included to better understand the aims of the study.

To begin addressing the gaps in the literature, this study aims to: 1) examine the association between access to recreational resources and LTPA across all counties in the United States and 2) investigate if violent crime rates moderate the association between access to recreational resources and LTPA in counties nationwide. This approach of examining community-level factors at the county level may lead to a better understanding of how proximity to recreational resources and objective measures of crime are related to LTPA engagement. Therefore, these aims will provide insight on how community-level factors correlate with LTPA engagement in counties across the United States. To address these aims, the following research questions and hypotheses were tested.

Research Question 1: Is access to recreational resources associated with LTPA across counties nationwide?

Hypothesis 1: It is hypothesized that there will be a positive association between access to recreational resources and LTPA (Kaczynski et al., 2014; Cerin et al., 2018; Schipperijn et al., 2017), adjusting for violent crime rates, median household income, and percent rurality, percent of Black/African American, Latina/o, and Non-Latina/o White populations in each county (Anderson et al., 2015; Kaczynski et al., 2011; Kari et al., 2015; Marquez et al., 2010; Martin et al., 2005; Parks et al., 2003; Sugiyama et al., 2015).

Research Question 2: Do violent crime rates moderate the hypothesized association between access to recreational resources and LTPA across counties nationwide?

Hypothesis 2: It is hypothesized that violent crime rates will moderate the hypothesized positive association between access to recreational resources and LTPA (Bracy et al., 2014; Perez et al., 2016; Sugiyama et al., 2014; Van Cauwenberg et al., 2017), such that counties with higher crime rates will show a diminished association between access to recreational resources and LTPA.

CHAPTER II

METHODS

Sample and Procedure

The units of measurement for the current study were all counties in the United States ($N = 3089$). Data were gathered from County Health Rankings & Roadmaps (CHRR; County Health Rankings & Roadmaps, n.d.) and the American Community Survey (ACS; U.S. Census Bureau, 2021). The CHRR is a website created through a collaboration between the Robert Wood Johnson Foundation and the University of Wisconsin's Population Health Institute. The CHRR data provide yearly estimates of various health behaviors, health outcomes, and other correlates of health outcomes at a county level. Data collected in 2016 from the two sources were joined together for analyses. Counties were determined by utilizing the Federal Information Process Standard county code.

Measures

Covariates

Percent Rurality of Counties. Percent rurality was based on census population estimates from 2010 of counties that were considered rural. Population estimates assessed the percent of rural area in a given county based on the census' definition of rurality, which is defined as "all population, housing; and territory not included within an urban area" (United States Census Bureau, 2020a). Urbanized areas were characterized by areas of 50,000 or more people, while urban clusters are characterized by at least 2,500 and less than 50,000 people in each area. The percent of a county that meets these criteria would be included in the percent of a county measured as rural. The variable used in the current

study was continuous with higher values reflecting a higher percentage of a county being defined as rural.

Percent of Latina/o County Population. Data on Latina/o population of counties were derived from a question that was asked of all respondents of the 2016 five-year estimate ACS. The question "Is Person 1 of Hispanic, Latino, or Spanish origin?" was asked of each household surveyed in the ACS (United States Census Bureau, 2021). Origin can also be defined many ways by the individual, and can include heritage, nationality, lineage, country of birth, or where an individual's ancestors were from before arriving in the United States (United States Census Bureau, 2021). Since Latina/o is an ethnicity, respondents could be identified ethnically as Latina/o and belong to any race. In the ACS, this item is originally coded as a population estimate for each county. For consistency, a percent of Latinas/os for each county was calculated by dividing the value for Latina/o residents by the total population of each county and multiplying by 100. For example, if there were 10 Latinas/os in a county of 100 residents, then the calculated percent would be 10%. The variable used in this study was continuous with higher values indicating higher percentages of Latina/o residents living in a county.

Percent of Black/African American County Population. County population estimates for Black/African American populations were collected from the 2016 five-year estimate ACS. The question asked was "What is Person 1's race?" for the head of the household. The categories for race reflect social definitions of race and are "not an attempt to define race biologically, anthropologically, or genetically" (United States Census Bureau, 2016, p. 110). If no response was provided for race, the race of another household member was imputed. Percent were calculated for Black/African American

residents exactly like previously stated for Latina/o residents. The variable used in this study was continuous with higher values indicating higher percentages of Black/African American residents living in a county.

Percent of Non-Latina/o White County Population. County population estimates for Non-Latina/o White residents were collected from the 2016 five-year estimate ACS. The question asked was "What is Person 1's race?" for the head of the household. If no response was provided for race, the race of another household member was imputed. Percent were calculated for Non-Latina/o White residents exactly like previously stated for Latina/o residents. The variable used in this study was continuous with higher values indicating higher percentages of non-Latina/o White residents living in a county.

Median Household Income. Median household incomes were calculated by examining the distribution of incomes of each household in a given county and splitting the distribution in two equal halves. The value for each county had half of households in a county earning more while half of households earned less that the calculated value (United States Census Bureau, 2016). The data were collected through the ACS based on 5-year estimates from 2016 for all counties of the 50 states. Median household income served as a continuous proxy of socio-economic status for the current study with higher values indicating higher incomes.

Independent Variable

Access to Recreational Resources. Data from business analyst, delorme map data, Environmental Systems Research Institute, and United States Census Tigerline Files from 2010 and 2016 were used to measure access to recreational resources in a county. While the variable in the CHRR is referred to as access to exercise opportunities, this study will

refer to the measure as access to recreational resources to better reflect how the variable was measured. The variable was measured by assessing the percent of individuals in a given county that live close to a location to engage in physical activity. Higher values for this continuous variable indicated that a higher percent of residents had access to a park or recreational facility in a county. Locations for physical activity were defined as parks or recreational facilities. Proximity to recreational resources were considered if individuals lived: "1) in a census block that was within a half mile of a park, 2) in an urban census block that is within one mile of a recreational facility, or 3) in a rural census block that is within three miles of a recreational facility" (County Health Rankings & Roadmaps, 2020a). The estimated data for the 2018 CHRR, which corresponded to the 2010 and 2016 access data, used the North American Information Classification System codes to provide estimates for counties nationwide.

Dependent Variable

Leisure-time Physical Activity. LTPA data were collected by the United States Diabetes Surveillance System in 2016. The 2020 CHRR data corresponds to BRFSS data from 2016 to create county-level estimates based on the percent of individuals that were inactive in a given county (County Health Rankings & Roadmaps, 2020b). From the BRFSS, to be physically inactive, participants had to answer "no" to the following question; "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?" (Centers for Disease Control and Prevention, 2020, p. 1). To get a measure of LTPA engagement in the past month, the percent of county residents that stated "yes" to the question was reported. Higher values for this continuous measure represented a

greater percentage of county residents engaging in any LTPA in the past month. For example, if 15% of a county reported no engagement in physical activities, 15% was subtracted from 100% to get a value of 85% of a county that indicated they participated in any LTPA in the past month. The question asked of participants is representative of LTPA since the physical activities mentioned are indicative of activities done in one's leisure time and not for transport or occupation. Limited research has been completed assessing the reliability and validity of the BRFSS' measurement of physical activity constructs in large-scale studies (Washburn et al., 2000). However, examination of both the reliability and validity of the BRFSS items to assess physical activity have been supported (Fulton et al., 2018; Yore et al., 2007). Washburn et al. (2000) state that there are no compelling reasons for modifying the items while there is limited support for the validity and reliability of the scale. This is primarily due to the assessment of the BRFSS' items validity and reliability indirectly from the examination of similar scales showing acceptable reliability and validity. However, this study's use of one item from the scale has not been psychometrically tested at a larger scale, such as counties in the United States.

Hypothesized Moderator Variable

Violent Crime Rates. Violent crime rates were measured as the number of violent crimes reported per 100,000 residents in a county (County Health Rankings & Roadmaps, 2020c). Rates measure the number of events (i.e., deaths, births, etc.) in a year divided by the average number of residents in a given county at risk during the year. Crimes are counted by where the crime occurred, rather than the residence of the perpetrator. Higher values indicated higher levels of violent crime in a county. Violent crime rates were

collected from the FBI's Uniform Crime Reporting Program, and reflect crimes reported to police in counties that are then reported to the FBI. Data gathered from 2020 from the CHRR used data from 2014 and 2016.

Analytic Plan

All analyses for the present study were conducted in R 4.0.3 (R Core Team, 2020), using the following packages: tidyverse (Wickham et al., 2019), psych (Revelle, 2020), inspectdf (Rushworth, 2020), sf (Pebesma, 2018), spdep (Bivand, Pebesma, & Gomez-Rubio, 2013; Bivand & Wong, 2018), tmap (Tennekes, 2018), rgdal (Bivand, Keitt, & Rowlingson, 2020), rgeos (Bivand & Rundel, 2020), spatialreg (Bivand, Hauke, & Kossowski, 2013; Bivand & Piras, 2015), and tidycensus (Walker & Herman, 2020). Missing data were limited, with the variable violent crime rates missing the most data with approximately seven percent of data missing. Missingness was handled using median imputation as a conservative approach to handling missing data with spatial autocorrelation. While multiple imputation is a better approach to handling missingness, similar to listwise deletion, these approaches can lead to biased estimates (Boehmke, Schilling, & Hays, 2015) for spatial data. Model assumptions for ordinary least squares (OLS) regressions were tested, including univariate normality, linearity, homoscedasticity, independence of residuals, and multicollinearity. Correlations of .7 or above were used as a threshold indicating multicollinearity. One of the two variables in the bivariate correlations with values over this threshold was removed from the analyses.

Spatial dependence is often measured through the Moran's *I* statistic with values ranging from -1 to 1. Greater positive values indicate spatial clustering between neighboring counties, greater negative values indicate spatial dispersion between

neighboring counties, and values closer to zero indicate random patterns in neighboring counties. A significant Moran's *I* value ($p < .05$) in the models tested suggests that the residuals of the OLS regressions violate the independence assumption (Cliff & Ord, 1973). Spatial regression models address the spatial dependence in an OLS regression by accounting for spatial dependence in the outcome (spatial lag model) or that the regression errors are spatially dependent and the variables included in the model do not account for spatial dependence alone (spatial error model; Chakraborty, 2009). The inclusion of a spatial parameter into the regression relies on a spatial weights matrix that determines the weight of each unit (i.e., county) in the analyses. For the current study, row-standardization matrices were used to determine weights. This method takes the weights and divides them by the row sum so each row sum equals one (Anselin, 2020). Queen adjacency weights were used in the row-standardized matrix as any point where two counties intersect at a county line suggests that the two counties are neighbors (Anselin, 2009). If spatial dependence was detected in the OLS regression, a spatial lag or spatial error model was conducted to address the spatial dependency. To determine which spatial regression to use, a Lagrange Multiplier (LM) diagnostic test was conducted on the OLS regression. Based on the findings of the LM test, if a spatial lag model was chosen as the appropriate model, the model would be defined as:

$$\boldsymbol{y} = \boldsymbol{\alpha} + \boldsymbol{\rho W y} + \sum_{\boldsymbol{k}} \boldsymbol{\beta_k X_k} + \boldsymbol{\mu}$$

Where *y* would represent LTPA engagement; α would be the intercept; ρ would be the spatial parameter tested; *Wy* is the spatially lagged dependent variable for the W spatial weights row-standardized matrix; β represents the coefficient for the *k* number of *X* predictor and control variables; and μ is the spatially independent residual term. If a

spatial error model was found to be appropriate based on the findings from the LM test, the spatial error model would be defined as:

$$\boldsymbol{y = \alpha + \sum_{k} \beta_k X_k + \lambda W e + \mu}$$

Where *y* would represent LTPA engagement; α would be the intercept; β represents the coefficient for the *k* number of *X* predictor and control variables; λ represents the spatial parameter for spatially autocorrelated errors; *W* is the spatial weights row-standardized matrix; *e* is the residual term from the OLS regression; and μ is the spatially independent residual term.

If the OLS regression assumptions were not met, three options were available to address spatial dependence in model residuals. The options were to: 1) include higher order queen adjacency weights, 2) stratify model using smaller geographical areas, such as U.S census regions (i.e., Northeast, South, West, Midwest; United States Census Bureau, 2020b), and/or 3) use spatial regressions to control for spatial dependence through the following models. In the first model, the association between access to recreational resources and LTPA was examined, while adjusting for violent crime, median household income, percent of a given county that is rural, and percent of Black/African American, Latina/o, and Non-Latina/o White populations in each county. The second model tested violent crime rates as a potential moderator of the hypothesized association between access to recreational resources and LTPA, while adjusting for median household income, percent of a given county that is rural, and percent of Black/African American, Latina/o, and Non-Latina/o White populations in each county.

To remain consistent across analyses, the model that tested violent crime rates as a potential moderator used the same spatial regression that was determined by the LM

test for the model answering the first aim. All continuous variables were centered for moderation analyses. If a significant interaction was found, simple slopes were analyzed at one standard deviation above (higher levels of the moderator) and below (lower levels of the moderator) the mean. Additionally, to examine the exact point at which a moderator has a significant effect on the association between access to recreational resources and LTPA engagement in the simple slopes analyses, Johnson-Neyman plots were created. In an attempt to make sure that the spatial regression addressed spatial dependence, the residuals of the spatial regression were tested using the Moran's *I* statistic with 9999 permutations. A non-statistically significant finding ($p > .05$) suggested that the spatial regression accounted for spatial dependence.

Exploratory Analyses

A post-hoc OLS regression was conducted investigating median household income as a moderator of the association between access to recreational resources and LTPA engagement, while adjusting for violent crime rates in a county, percent of a given county that is rural, percent of Black/African American, Latina/o, and Non-Latina/o White populations within a given county. Consistent with the second aim, either a spatial lag model or a spatial error model was conducted depending on results from the LM tests. The appropriate spatial regression was conducted to address whether median household income moderated the association between access to recreational resources and LTPA engagement while accounting for spatial dependence.

CHAPTER III

RESULTS

Preliminary Findings

Table 1 presents the descriptive statistics for the county-level variables that were used in the spatial regression models. The Moran's *I* values in Table 1 suggest spatial dependence in the variables examined for the United States and the four U.S. census regions. The West had the highest LTPA (77.41%) compared to other regions, while the South had the lowest LTPA (70.12%). The South also had the lowest access to recreational resources (57.61%) compared to other regions. The Midwest had the lowest violent crime rates (196.88) compared to the other regions, especially compared to the South (290.20) with the highest violent crime rates. The region with the highest median household income was the Northeast ($57,790). The Midwest had the highest percent of rurality in counties (62.98%) and the highest non-Latina/o White adult population (91.69%). There was a great amount of variation in the percent of Black/African American and Latina/o populations in the four regions. For instance, the South had the largest Black/African American adult population (16.51%) compared to the 1.32% in the West. For Latina/o populations, the West had the highest Latina/o population (16.53%) compared to other regions. Additionally, due to a strong correlation that indicated multicollinearity between percent of Black/African American populations and non-Latina/o White populations ($r = .828$, $p < .001$), the non-Latina/o White population variable was dropped from analyses.

Figure 1 shows the significant spatial dependence in the residuals of the OLS regression examining counties nationwide (Moran's $I = .286$, $p < .001$). To address

spatial dependence in the residuals, first, higher order queen adjacency weights were created to find a peak Moran's *I* value. Testing cumulative higher order queen adjacency weights did not reveal a peak Moran's *I* value. Thus, regional analyses of the four U.S. Census regions were conducted to address the spatial dependence. The regional OLS regressions for the Northeast (Moran's $I = .259$, $p < .001$), South (Moran's $I = .147$, $p < .001$), West (Moran's $I = .198$, $p < .001$), and Midwest (Moran's $I = .250$, $p < .001$) counties all showed spatial dependence from the global Moran's *I* values (see Appendix). Lagrange multiplier tests for the separate regions suggested spatial error models for counties in the Northeast (LM = 4.374, $p = .036$) and the Midwest (LM = 18.613, $p < .001$) and spatial lag models for the South (LM = 10.486, $p = .001$) and Western counties (LM = 43.656, $p < .001$). Table 2 presents the matrices used for all counties in the United States and each region. Table 2 also includes the description of neighbors, which includes the number of counties that share an adjacent border or a point with at least one other county, the number of counties that are not adjacent or share a point with another county, the average number of times a county shares a border or a point with other counties, and the most times a county shares a border or a point with other counties.

Study Aim 1 Results

Table 3 shows that access to recreational resources was positively associated with LTPA engagement in the Northeast ($b = 0.058$, $p = .001$), South ($b = 0.025$, $p < .001$), and the West ($b = 0.046$, $p < .001$) adjusting for violent crime rates, median household income, percent rurality, and percent of Black/African American and Latina/o populations. In the Midwest, there was no significant association between access to recreational resources and LTPA engagement ($b = 0.014$, $p = .060$). The residuals in each

region-specific spatial regression did not show any evidence of spatial dependence in the models as seen in Table 3.

Significant associations were found between covariates in the model and LTPA engagement. Median household income showed a positive association with LTPA engagement in the Northeast ($b = 0.135$, $p < .001$), South ($b = 0.143$, $p < .001$), West ($b = 0.098$, $p < .001$), and Midwest ($b = 0.165$, $p < .001$). Violent crime rates were negatively associated with LTPA engagement in the West only ($b = -0.003$, $p = .014$). In the Northeast ($b = -0.002$, $p = .511$), South ($b = 0.000$, $p = .578$), and the Midwest ($b = -0.001$, $p = .138$), this association was not statistically significant. Rurality was only found to be significantly and negatively associated with LTPA engagement in the West ($b = -0.027$, $p = .001$) and the Midwest ($b = -0.033$, $p < .001$). In the Northeast ($b = 0.010$, $p = .434$) and the South ($b = -0.006$, $p = .322$) the association was not statistically significant. In the Midwest, percent of Black/African American residents was positively associated with LTPA engagement ($b = 0.073$, $p = .039$). The Northeast ($b = 0.084$, $p = .117$), South ($b = 0.084$, $p = .117$), West ($b = -0.030$, $p = .804$) did not show a statistically significant association between percent of Black/African American residents and LTPA engagement. Percent of Latina/o residents was positively associated with LTPA engagement in the South ($b = 0.044$, $p < .001$) and negatively associated with LTPA engagement the Northeast ($b = -0.126$, $p = .003$). This association was not statistically significant in the Western ($b = -0.003$, $p = .804$) and Midwestern regions ($b = -0.045$, $p = .072$).

Study Aim 2 Results

Table 4 shows violent crime rates moderated the association between access to recreational resources and LTPA engagement in the Northeast only ($b = 0.0002$, $p = .032$)

adjusting for median household income, percent rurality, and percent of Black/African American and Latina/o populations. Simple slopes (Figure 2) indicate that among Northeastern counties with high levels of violent crime rates (one standard deviation above the mean), access to recreational resources resulted in a positive association with LTPA engagement ($b = 0.108$, $p < .001$). Among Northeastern counties with low levels of crime (one standard deviation below the mean), the association between access to recreational resources and LTPA engagement was not statistically significant ($b = 0.036$, $p = .075$). Additional Johnson-Neyman analyses (Figure 3) showed that in counties with violent crime rates that were 143.32 and lower than the average violent crime rate per 100,000 individuals in the Northeast, there was not a statistically significant positive association between access to recreational resources and LTPA engagement. When violent crime rates were higher than this threshold, there was a statistically significant positive association between access to recreational resources and LTPA engagement. Violent crime rates did not moderate the association between access to recreational resources and LTPA engagement in the South ($b = 0.000$, $p = .272$), West ($b = 0.000$, $p = .453$), or the Midwest ($b = 0.000$, $p = .623$).

After adding the interaction between violent crime rates and access to recreational resources on LTPA engagement, most associations between covariates and LTPA engagement remained the same. The only association to differ was the association between percent Black/African American and LTPA engagement in the Midwest. The positive association was no longer statistically significant as a result of including violent crime rates as a moderator ($b = 0.066$, $p = .082$).

Exploratory Results

As shown in Table 5, median household income was found to moderate the association between access to recreational resources and LTPA engagement in the West ($b = 0.002$, $p = .003$) and the Midwest only ($b = 0.001$, $p = .040$) adjusting for violent crime rates, percent rurality, and percent of Black/African American and Latina/o populations. Figure 4 shows that among counties with higher median household incomes in the West ($b = 0.080$, $p < .001$), the positive association between access to recreational resources and LTPA engagement was stronger than Western counties with lower median household incomes ($b = 0.028$, $p = .019$). Johnson-Neyman analyses (Figure 5) showed that Western counties with a median household income that was $14,750 or lower than the average median household income for the region, there was not a statistically significant positive association between access to recreational resources and LTPA engagement. When the median household income was greater than this threshold, there was a significant positive association between access to recreational resources AND LTPA engagement in the West. Figure 6 shows that in the Midwest, at high median household incomes, access to recreational resources was positively associated with LTPA engagement ($b = 0.029$, $p = .005$). At low median household incomes, there was no significant association between access to recreational resources and LTPA engagement ($b = 0.006$, $p = .504$). In the Midwest, Johnson-Neyman analyses (Figure 7) showed that Midwestern counties with a median household income that was $1,780 or lower than the regional average, there was not a signification positive association between access to recreational resources and LTPA engagement. Midwestern counties with a median household income above this thresdhold, there was a statistically significant positive association between access to recreational resources and LTPA engagement. In the

Northeast (b = -0.002, p = .136) and the South (b = 0.000, p = .611), median household income did not moderate the association between access to recreational resources and LTPA engagement.

After adding the interaction between median household income and access to recreational resources on LTPA engagement, most associations between covariates and LTPA engagement remained the same. A significant direct association was found in the Midwest between access to recreational resources and LTPA engagement (b = 0.017, p = .026) after including median household income as a moderator. Additionally, the positive association between percent Black/African American and LTPA engagement in the Midwest was also statistically significant again (b = 0.075, p = .034).

CHAPTER IV

DISCUSSION

This study examined the association between access to recreational resources and LTPA engagement in counties across the United States and evaluated violent crime rates as a potential moderator of the hypothesized positive association between access to recreational resources and LTPA engagement across these U.S. counties. Consistent with the goals of the CHRR, this study employed CHRR data to advance our understanding of community-level factors correlated with LTPA engagement in counties across the United States. Details follow on how this study's findings can inform future research and community-level policy and intervention efforts to promote LTPA engagement and, in turn, improve population health (Dwyer-Lindgren et al., 2013).

Consistent with the hypothesis and past literature (Coutts et al., 2013; Gidlow et al., 2019; Gordon-Larsen et al., 2006; Huston et al., 2003; Kaczynski et al., 2014; Schipperijn et al., 2017), greater access to recreational resources was significantly associated with more engagement in LTPA across counties in the Northeastern, Southern, and Western regions of the United States. Studies that have primarily focused on LTPA rather than overall physical activity have found that greater access to trails, built environment characteristics (e.g., streetlights), and green space was associated with engaging in more LTPA (Coutts et al., 2013; Huston et al., 2003). The most similar study to the current study found a positive association between access to recreational resources and overall physical activity rates in older adult populations across all counties within the United States (Sato et al., 2019). Similar to Sato et al.'s finding, the current study supports that throughout the United States, having access to recreational resources near

one's residence could matter in regard to LTPA engagement on higher population levels, such as counties. Such findings could inform decision-making regarding zoning policies that influence access to commercial and public recreational resources, or investment decisions regarding the creation of parks or trails. Future studies can expand on this research by examining how specific components of recreational resources may be associated with engaging in LTPA. For example, Heinrich et al. (2017) found that adults who had greater access to a recreational facility or physical activity equipment, such as one's home, a gym, parks, and community centers, were more likely to engage in several intensities of LTPA engagement.

However, counter to the hypothesis, access to recreational resources was not significantly associated with LTPA engagement in the Midwestern counties. This null finding may be due to access to recreational resources only relating to LTPA engagement in the Midwest under certain circumstances. For instance, other studies have shown that the Midwest has significantly fewer physical fitness facilities compared to other regions (Powell et al., 2006). It is possible that other community-level factors may play a crucial role in this association. The equity framework (Humphreys & Ogilvie, 2013; O'Neill et al., 2014) explains that multiple factors may interact to cause inequities in health behaviors, like LTPA engagement. Higher incomes have been shown to be associated with greater access to various recreational resources (Powell et al., 2006). It is possible that in Midwestern counties, the association between access to recreational resources and LTPA engagement is dependent on median household income of the county.

Within each region, there were significant associations between the relevant covariates and LTPA engagement. For instance, median household income was positively

associated with LTPA engagement in each region. This has been found in past literature where individuals in lower-income areas engage in less LTPA (Kari et al., 2015). Some regional differences were also found. Consistent with past literature, less LTPA engagement was reported in counties that were more rural in the West and Midwest (Martin et al., 2005).

Interestingly, counties with more Black/African American residents engaged in more LTPA engagement in the Midwest only. This finding is inconsistent with past literature (Kaczynski et al., 2011; Marquez et al., 2010), which found that Black/African American adults engage in less physical activity than non-Latina/o White adults. One possibility for why Black/African American adults are not engaging as much LTPA is that they are not engaging in LTPA in parks or other recreational facilities due to fear of racial conflicts or feeling unwelcome (Stanis et al., 2009). Black/African American adults may experience discrimination and engage in LTPA in neighborhoods rather than use parks or recreational facilities. Interestingly, counties with more Latinas/os in the Northeast were found to engage in less LTPA while counties with more Latinas/os in the South engaged in more LTPA. Marquez et al. (2010) found that Latina/o adults engaged in less physical activity than non-Latina/o White adults. Latinas/os were also more likely to have occupations that require more physical labor compared to other racial/ethnic groups. One potential reason for why Latinas/os engaged in more or less LTPA based on the region could be due to the Latina/o subgroups that predominately live in the Northeast and the South. While not representative of the entirety of both the Northeast and the South, The Hispanic Community Health Study examined Latinas/os in Miami, the Bronx,

and Chicago and found differences in the amount of time spent engaging in moderate-to-vigorous physical activity between Latina/o subgroups (Arredondo et al., 2016).

The United States' Western region was found to have the largest percentage of Latina/o residents (see Table 1). Historically, Latinas/os that settled across the United States have relied on social capital of those they knew who could provide employment opportunities (Smith & Winders, 2007). In the 1990s Mexicans and other Latina/o populations began migrating and immigrating to other regions of the United States, such as to the South (Hernandez-Leon & Zuniga, 2003). The growth of Latinas/os in the South began to create residential segregation in communities, thus creating enclaves of Latinas/os. This separation from other races/ethnicities created large amounts of dissimilarity between Black/African American populations and Latina/o populations (Rodriguez, 2012). This separation from other racial/ethnic groups may have led to social groups with similar health behaviors and values with other Latinas/os, resulting in less LTPA engagement (Osypuk et al., 2009). Unhealthy behaviors, like not engaging in enough LTPA, may be changing as Latinas/os become more acculturated. Using national datasets, Ham et al. (2007) found that Latinas/os engaged in more LTPA as they became more acculturated. Additionally, different Latina/o subgroups engage in different amounts of physical activity compared to one another (Marquez et al., 2010). This may be the result of different characteristics of Latinas/os from these different countries, like how some Latinas/os immigrated due to economic factors while other Latina/o groups (e.g., Cubans) immigrated as refugees (Durand et al., 2006). This could potentially explain why Mexicans are more likely to engage in more occupational physical activity compared to other Latina/o subgroups, since most Mexicans that migrated came into the

United States during periods of needed manual labor from the United States. It could also be that other subgroups, like Cubans, were accepted as refugees by the United States and had easier transitions into U.S. culture due to early arrival of Cuban immigrants that had professional backgrounds, such as physicians (Rothe & Pumariega, 2008). Rothe and Pumariega (2008) also explain that Cubans are beginning to directly resemble the United States culture, which could also be an adoption of more engagement in LTPA.

Inconsistent with the second hypothesis and previous literature (Bracy et al., 2014; Perez et al., 2016), violent crime rates did not moderate the positive association between access to recreational resources and LTPA engagement in the South, West, and Midwest. However, previous studies that found significant interactions examined built environment characteristics (e.g., land use mix, residential density, sidewalk maintenance) and perceptions of overall crime and safety, which differed from the current study's examination of access to recreational resources and violent crime rates (Bracy et al., 2014; Perez et al., 2016). These operational differences in the constructs can provide insight as to why the current study did not find a significant interaction. It is possible that the interactive effect of the built environment and perceptions of crime in a county are more important to LTPA engagement than having access to recreational resources. Foster & Giles-Corti (2008) argued that perceptions of crime may have a more powerful effect on behavior than objective measures of crime. Another possibility is that by examining violent crimes rates as a composite measure, it may not capture the nuances of how specific types of violent crimes (e.g., homicide, rape, robbery, assault) may interact with access to recreational resources on LTPA engagement at the county level. For instance, Janke et al. (2016) found that violent crimes that involved injuries were

associated with less overall physical activity as these violent crimes are more prevalent than other violent crimes (e.g., homicides). One last possibility to the null findings in these regions is that there may be a lot of variability within counties regarding the reporting of violent crime rates. For instance, crime in major metropolitan areas may impact the number of violent crimes reported for a county when the rest of that county could have low violent crime rates. This variability within counties could also be from specific neighborhoods with higher crime rates influencing these county crime rate values compared to other neighborhoods in that county. Future studies should consider incorporating perceptions of crime to test as a moderator rather than relying solely on objective measures in the association between access to recreational resources and LTPA engagement (McGinn et al., 2008). Studies that focus on units of measurement (e.g., individuals, neighborhoods, cities) other than counties should examine both objectively measured county- or state-level crime rates (e.g., assault, robberies, burglaries, homicide, rape) as well as perceptions of crime as potential moderators.

In the Northeast only, violent crime rates did moderate the association between access to recreational resources and LTPA engagement. Specifically, counties with high violent crime rates were reported to have greater access to recreational resources associated with more LTPA engagement. This finding was not in the hypothesized direction but is consistent with other studies that have found crime as a significant moderator (Bracy et al., 2014; Perez et al., 2016). Bracy et al.'s (2014) findings were in the same direction as the current study, with greater walkability associated with more LTPA engagement in individuals who perceived their neighborhoods to be less safe. Perez et al. (2016) found that among individuals with higher perceived safety, better

maintained sidewalks were associated with more LTPA engagement. While this association was not identified in counties with low violent crime rates, it is possible that in high violent crime rate counties there are alternative ways of engaging in LTPA. For example, in counties with higher violent crime rates, individuals may be engaging in LTPA in monitored spaces, like gyms rather than in unmonitored spaces, such as parks or trails. Another possibility is that in communities with high violent crime rates, those that live in those counties may not be able to afford to move to communities with less violent crime rates. Since those in these communities may not be able to move out of their violent areas, they may adapt to the high levels of violent crime. For instance, individuals may engage in LTPA earlier in the day and utilize resources during those times because it is safer. This may be a reason for greater access to recreational resources being associated with more LTPA engagement in Northeastern counties with higher crime rates. Future studies should examine what types of recreational resources are associated with LTPA engagement in communities with higher and lower violent crime rates.

Exploratory analyses identified median household income as a moderator of the association between access to recreational resources and LTPA engagement in the West and Midwest. At lower and higher household incomes, greater access to recreational resources was associated with more LTPA engagement in Western counties, where counties with higher median household incomes showed a stronger positive association than counties with lower median household incomes. This finding is consistent with Adkins et al. (2017), which found a supportive built environment being associated with more physical activity for advantaged groups with higher incomes compared to disadvantaged groups with lower incomes. One reason for both higher and lower incomes

showing this significant positive association is the type of recreational resource that is being used. For instance, low-income communities may be relying on free recreational resources (e.g., parks and trails) to engage in LTPA while higher-income communities may rely on pay-for-use recreational resources (e.g., gyms) to engage in LTPA (Powell et al., 2006; Wilson et al., 2004). It is also possible that those with higher incomes may have greater access to recreational facilities, parks, and trails and may use all of these resources in comparison to the resources available to lower-income communities. Sallis et al. (2011) found income inequities in regard to access, where individuals from higher income neighborhoods had greater access to recreational resources as well as several LTPA-supportive? built environment characteristics (e.g., pedestrian/biking facilities). These potential explanations are speculation as there is scarce literature examining socioeconomic status as a moderator of the association between access to recreational resources and LTPA engagement (Adkins et al. 2017) and no known literature to the author on median household income as a moderator of access to recreational resources and physical activity engagement.

In the Midwest, it was only higher income counties that showed a significant association between access to recreational resources and LTPA engagement. This adds to the null direct association of access to recreational resources and LTPA engagement in the Midwest. Past literature has noted that while the number of recreational facilities were similar in Midwestern census tracts with differing socioeconomic levels, it was higher socioeconomic areas that had greater numbers of free-for-use recreational resources than medium and low socioeconomic areas (Estabrooks, Lee, & Gyuresik, 2003). In the Midwest, higher income counties may not only have more access to free-to-use

recreational resources, but they may also have the financial options to have access to paid recreational facilities (e.g., gyms) and gym equipment. Future studies should investigate how much LTPA is engaged in using public recreational resources or using private recreational facilities.

The moderation findings from the West and the Midwest provided a broad understanding that greater access to recreational resources is associated with more LTPA engagement in counties with greater median household income. Other studies have provided additional details into low- and high-income areas and access to recreational resources. For instance, in Kansas City, Missouri, lower income census tracts had more parks but had reduced quality of the recreational resources available compared to higher income census tracts (Vaughan et al., 2013). Examining census tracts in New York, North Carolina, and Maryland revealed similar findings, with lower income census tracts being 4.5 times less likely to have access to recreational resources compared to higher income census tracts (Moore et al., 2008). Similarly, in a rural county in South Carolina, individuals in neighborhoods with lower socioeconomic statuses perceived their neighborhoods as having less access to public recreational resources compared to neighborhoods with higher socioeconomic statuses (Wilson et al., 2004). In addition, across 12 cities in eight different countries, having greater access to parks was associated with more LTPA engagement (Schipperijn et al., 2017). This study showed that in middle and higher income cities, access to recreational resources is important for more engagement in LTPA. However, further work is needed to collect data in neighborhoods, cities, and census tracts to be able to make better comparisons between studies on low

and high income areas rather than comparing large scale studies examining several cities and a singular county.

The findings from this study may be useful for implementing policies in counties and states across the United States. Several states have created or updated outdoor recreation plans to promote physical activity opportunities. For example, Illinois has their Statewide Comprehensive Outdoor Recreation Plan, which included a survey on individuals' perceptions of trails and other recreational resources (Illinois Department of Natural Resources, 2021). However, many of these plans do not address the inequities in access to recreational resources in counties across each state. For instance, the state of Illinois has conducted surveys to investigate recreational resource use and health behaviors; however, the respondents were older and predominately non-Latina/o White adults (75%). Illinois has also devoted $24.9 million to renovating public parks and recreational facilities. The findings from this study, primarily the finding that median household income moderates the association between access to recreational resources and LTPA engagement in the West and Midwest, can inform how these states prioritize funds to address the inequities in lower income neighborhoods and cities. An explanation for the finding in the West where both low- and high-income areas were found to have significant positive associations between access to recreational resources and LTPA engagement could be due to programs that are promoting physical activity while addressing inequities in access for communities. Programs like *The City Project* in Los Angeles and *Learning Landscapes* in Denver have already been created to promote physical activity in local communities. The City Project's main mission is to create parks in disadvantaged areas of Los Angeles. Building on the findings from the current study,

these programs could collect data on smaller scales, such as within specific neighborhoods or cities to have a more comprehensive examination of the association between access to recreational resources and LTPA with data at various levels.

Strengths and Limitations

There were notable strengths to the current study. One strength is that this study used county-level data across regions of the United States to advance the literature and understanding of community-level factors associated with LTPA engagement. For example, this study was one of the first studies to examine the association between access to recreational resources and LTPA using counties as the unit of measurement. This study also draws attention that there are income inequities in the West and Midwest that need more attention. This study also diverged from using overall physical activity and instead focused on LTPA engagement, particularly due to the health benefits from LTPA being greater than other physical activity domains (Samitz et al., 2011). Additionally, this study was one of the first studies to use violent crime rates, rather than a global measure of crime, such as overall crime rates. It was also the first study to examine an objective measure of crime, in the form of violent crime rates, rather than a global measure of crime as a moderator in the association between access to recreational resources and LTPA engagement. An additional strength for this study was the statistical approach. By separating the United States into regions and utilizing spatial regression technique, this study was successful in addressing violated assumptions of typical linear regression. The last strength of the current study was the large sample size, which allowed for enough power to conduct moderation analyses, which is often underpowered (Shieh, 2009).

Overall, the findings from this study can inform LTPA promotion efforts at county and regional levels in the United States.

While this study had several strengths, this study also has limitations. First, the cross-sectional design does not allow for causal inferences to be made on the impact that access to recreational resources, violent crime rates, and median household income have on LTPA engagement and must rely on correlations. Future studies can examine causal predictions by examining these associations using longitudinal study designs. Second, the lack of evidence supporting that the measures are shown to provide valid responses limits the conclusions that can be drawn from the data. For example, LTPA engagement was measured by a single item that asks if individuals engaged in any physical activities in the past month other than during their jobs. The original BRFSS items have been utilized for decades without any psychometric support (Washburn et al., 2000). Although the LTPA item has been used before (Dwyer-Lindgren et al., 2013), the item allows for more variation in the amount of LTPA individuals in a given county are engaging in. For example, some individuals may walk once in the past month, while other individuals can walk every day, and they would both be able to state that they have been active in the past month. This measure may not be as accurate compared to a validated self-report measure of LTPA or an objective measure of activity (e.g., accelerometer). Another limitation is that examining these associations on a county level nationwide may provide a broader look into how these community-level factors are associated with LTPA engagement in four separate regions, there may be wide amounts of variability within counties on all variables that this study does not account for and should be further studied. The importance of this study stems from the need to examine the association

between access to recreational and LTPA engagement along with the investigation of moderators on a larger scale than has been previously examined. By examining at the county level, studies can provide evidence to states on the importance of greater access to recreational resources and how it is associated with more LTPA engagement. County-level studies can then inform county, state, and regional policies and programs that aim to promote LTPA and address population-level health equity.

Conclusion

This is the first study that has focused on the associations between access to recreational resources, violent crimes rates, and median household income on LTPA engagement across counties nationwide. This study suggests that access to recreational resources may be an important physical community-level factor for LTPA engagement among three U.S. census regions in the United States. In addition, greater access to recreational resources was associated with more LTPA engagement among counties in the Northeast with higher rates of violent crimes. Overall, median household income may be a more important moderator compared to violent crime rates, as income moderated the association between access to recreational resources and LTPA engagement in the West and Midwest. Specifically, in higher income counties, there was a stronger association between access to recreational resources and LTPA engagement. In the Midwest, this positive association was only seen in counties with higher median household incomes. Future research should consider gathering additional population-level data to understand how these community-level factors correlate with LTPA engagement. For example, including data from cities or census tracts may help provide a more comprehensive examination at specific factors that are correlated with LTPA engagement. It may also be

important to examine individual-level LTPA rather than LTPA at the county level. This study's findings can inform county and regional LTPA promotion efforts in order to ultimately improve population health in the United States.

APPENDIX: TABLES AND FIGURES

Table 1

Descriptive Statistics for County-level Leisure-time Physical Activity, Access to Recreational Resources, Moderators, and Covariates used in Spatial Regression Analyses for Counties Across the United States as well as Stratified Regional Analyses

Variable	*M*	*SD*	Min	Max	Moran's *I*
United States (*N* = 3089)					
LTPA (%)	72.59	5.65	50.10	90.50	.484***
Recreational resources (%)	63.02	23.14	0.00	100.00	.326***
Violent crime rates	248.37	186.49	0.00	1819.51	.289***
Median household income	47.79	12.39	18.97	125.67	.611***
Rurality (%)	58.59	31.20	0.00	100.00	.315***
Non-Latina/o White (%)	83.79	16.23	9.05	100.00	.655***
Black/African American (%)	8.88	14.36	0.00	86.18	.780***
Latina/o (%)	8.89	13.51	0.00	98.96	.802***
Northeast (*N* = 216)					
LTPA (%)	75.80	4.07	64.80	85.60	.314***
Recreational resources (%)	72.07	21.55	1.95	100.00	.631***
Violent crime rates	212.92	154.80	16.34	1226.43	.183***
Median household income	57.79	14.09	35.30	108.18	.579***
Rurality (%)	43.57	30.15	0.00	100.00	.568***
Non-Latina/o White (%)	87.30	12.79	20.56	98.03	.566***
Black/African American (%)	5.50	7.41	0.00	48.35	.317***

Latina/o (%)	6.49	7.94	0.68	55.41	.610***
South (N = 1408)					
LTPA (%)	70.12	5.44	50.10	86.60	.354***
Recreational resources (%)	57.61	24.46	0.00	100.00	.267***
Violent crime rates	290.20	202.00	0.00	1566.31	.285***
Median household income	43.94	12.60	18.97	125.67	.632***
Rurality (%)	59.74	30.61	0.00	100.00	.273***
Non-Latina/o White (%)	77.06	17.86	12.62	100.00	.697***
Black/African American (%)	16.51	17.96	0.00	86.18	.745***
Latina/o (%)	10.21	15.68	0.00	98.96	.864***
West (N = 420)					
LTPA (%)	77.41	5.14	60.40	90.50	.328***
Recreational resources (%)	70.18	22.38	0.00	100.00	.226***
Violent crime rates	253.71	171.95	0.00	1006.66	.335***
Median household income	50.45	13.11	21.19	105.90	.500****
Rurality (%)	51.89	33.13	0.00	100.00	.269***
Non-Latina/o White (%)	85.05	14.65	11.05	100.00	.356***
Black/African American (%)	1.32	1.88	0.00	14.13	.377***
Latina/o (%)	16.53	16.76	0.00	83.22	.652***
Midwest (N = 1045)					
LTPA (%)	73.23	4.49	56.20	86.30	.330***
Recreational resources (%)	65.40	19.96	0.00	99.90	.288***
Violent crime rates	196.88	160.97	0.00	1819.51	.175***

Median household income	49.83	9.11	29.07	94.23	.502***
Rurality (%)	62.98	30.02	0.00	100.00	.268***
Non-Latina/o White (%)	91.69	10.25	9.05	100.00	.265***
Black/African American (%)	2.48	4.60	0.00	47.90	.313***
Latina/o (%)	4.34	5.70	0.00	58.98	.477***

Note. LTPA = Leisure-time Physical Activity. M = Mean. SD = Standard Deviation.

Median household income was reported as thousands.

*** $p < .001$

Table 2

Distribution of Neighbors for Counties across the United States and for each Region using First Order Queen Adjacency Weights

	All Counties	Northeast	South	West	Midwest
Number of counties with at least one neighbor	3077	213	1408	410	1045
Counties with no linked neighbors	12	3	0	10	0
Average number of links between neighbors	5.768	5.046	5.655	5.371	5.765
Most linked neighbors (Number of counties)	14 (1)	10 (1)	10 (5)	14 (1)	10 (2)

Note. Links are where adjacent counties share a border or a point.

Table 3

Spatial Regressions Examining Access to Recreational Resources and Covariates Associated with Leisure-time Physical Activity in Region-Specific Counties Across the United States

	Northeast (*N* = 216)			South (*N* = 1408)			West (*N* = 420)			Midwest (*N* = 1045)		
Variable	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*
Intercept	-0.034	0.440	-0.076	-0.001	0.115	-0.011	0.089	0.192	0.464	0.021	0.211	0.099
Recreational resources	0.058**	0.018	3.306	0.025***	0.006	4.082	0.046***	0.010	4.565	0.014	0.008	1.881
Violent crime rates	-0.002	0.002	-0.657	0.000	0.001	-0.557	-0.003*	0.001	-2.466	-0.001	0.001	-1.483
Median household income	0.135***	0.024	5.534	0.143***	0.012	12.111	0.098***	0.017	5.721	0.165***	0.017	9.964
Rurality	0.010	0.012	0.782	-0.006	0.006	-0.990	-0.027**	0.008	-3.480	-0.033***	0.006	-5.880
Black/ African American	0.084	0.053	1.568	-0.004	0.008	-0.562	-0.006	0.116	-0.053	0.073*	0.035	2.068
Latina/o	-0.126**	0.043	-2.945	0.044***	0.008	5.315	-0.003	0.013	-0.248	-0.045	0.025	-1.799
Rho					.301***			.362***				
Lambda		.544***									.475***	
Log likelihood		-552.094			-4074.609			-1175.548			-2838.756	
Nagelkerke pseudo R^2		.412			.360			.403			.339	
AIC		1122.200			8167.200			2369.100			5695.500	
Moran's I of residuals		-.021			-.004			.004			-.034	

Note. AIC = Akaike Information Criterion. SE = Standard Error. *p* = p value showing statistical significance at the .05 level. Unstandardized regression coefficients are reported. AIC is a measure of model fit that accounts for goodness of fit of the model with data and the simplicity of the model.

*** $p < .001$ ** $p < .01$ * $p < .05$

Table 4

Spatial Regressions Testing Violent Crime Rates as a Moderator of the Association between Access to Recreational Resources and Leisure-time Physical Activity in Region-Specific Counties Across the United States

	Northeast (N = 216)			South (N = 1408)			West (N = 420)			Midwest (N = 1045)		
Variable	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*
Intercept	-0.359	0.460	-0.780	-0.012	0.116	-0.101	0.074	0.193	0.383	0.008	0.212	0.037
Access to Recreational resources	0.072***	0.019	3.877	0.026***	0.006	40153	0.047***	0.010	4.621	0.015	0.008	1.931
Violent crime rates	-0.006	0.003	-1.814	0.000	0.001	-0.513	-0.003*	0.001	-2.263	-0.001	0.001	-1.530
Median household income	0.131***	0.024	5.426	0.144***	0.012	12.134	0.098***	0.017	5.746	0.165***	0.017	9.976
Rurality	0.005	0.012	0.396	-0.005	0.006	-0.856	-0.026**	0.008	-3.466	-0.033***	0.006	-5.891
Black/ African American	0.055	0.054	1.017	-0.004	0.008	-0.566	-0.030	0.120	-0.248	0.066	0.038	1.739
Latina/o	-0.133**	0.042	-3.131	0.045***	0.008	5.341	-0.003	0.013	-0.231	-0.045	0.025	-1.812
Access to Recreational resources x Violent Crime Rates	0.0002*	0.0001	2.141	0.000	0.000	1.099	0.000	0.000	0.751	0.000	0.000	0.491
Rho					.301***			.365***				
Lambda		.543***									.474***	
Log likelihood		-549.826			-4074.004			-1175.267			-2838.636	
Nagelkerke pseudo R^2		.424			.360			.403			.340	
AIC		1119.700			8168			2370.500			5697.3	

Moran's I of residuals	-.018	-.003	.005	-.033

Note. AIC = Akaike Information Criterion. SE = Standard Error. *p* = p value showing statistical significance at the .05 level. Unstandardized regression coefficients are reported. AIC is a measure of model fit that accounts for goodness of fit of the model with data and the simplicity of the model.

*** $p < .001$ ** $p < .01$ * $p < .05$

Table 5

Spatial Regressions Testing Median Household Income as a Moderator of the Association between Access to Recreational Resources and Leisure-time Physical Activity in Region-Specific Counties Across the United States

	Northeast (N = 216)			South (N = 1408)			West (N = 420)			Midwest (N = 1045)		
Variable	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*	*b*	*SE*	*z*
Intercept	0.277	0.464	0.597	-0.023	0.123	-0.185	-0.108	0.202	-0.532	-0.042	0.212	-0.198
Access to Recreational resources	0.048*	0.019	2.527	0.026***	0.006	4.106	0.054***	0.010	5.225	0.017*	0.008	2.221
Median household income	0.158***	0.029	5.377	0.140***	0.013	10.748	0.084***	0.018	4.718	0.156***	0.017	9.212
Violent crime rates	-0.001	0.002	-0.524	0.000	0.001	-0.523	-0.003*	0.001	-2.074	-0.001	0.001	-1.289
Rurality	0.009	0.012	0.700	-0.005	0.006	-0.943	-0.026**	0.008	-3.393	-0.031***	0.006	-5.448
Black/ African American	0.072	0.054	1.348	-0.005	0.008	-0.667	-0.051	0.116	-0.437	0.075*	0.035	2.117
Latina/o	-0.135**	0.042	-3.183	0.044***	0.008	5.318	-0.008	0.013	-0.606	-0.045	0.025	-1.814
Access to Recreational resources x Median Household Income	-0.002	0.001	-1.492	0.000	0.000	0.508	0.002**	0.001	2.953	0.001*	0.001	2.059
Rho					.300***			.339***				
Lambda		.520***									.473***	
Log likelihood		-551.031			-4074.479			-1171.291			-2836.642	
Nagelkerke pseudo R^2		.418			.360			.415			.342	
AIC		1122.1			8169			2362.600			5693.300	

Moran's I of residuals	-.020	-.004	.001	-.034

Note. AIC = Akaike Information Criterion. SE = Standard Error. *p* = p value showing statistical significance at the .05 level. Unstandardized regression coefficients are reported. AIC is a measure of model fit that accounts for goodness of fit of the model with data and the simplicity of the model.

*** $p < .001$ ** $p < .01$ * $p < .05$

Figure 1

Spatial Distribution of Counties in the United States from the Main Effects Ordinary Least Squares Regression Residuals

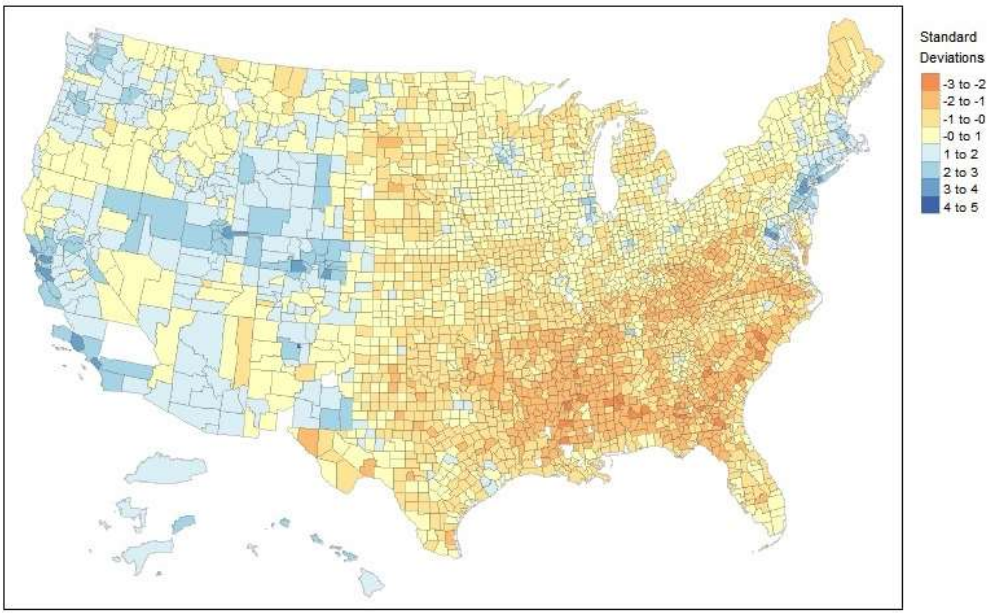
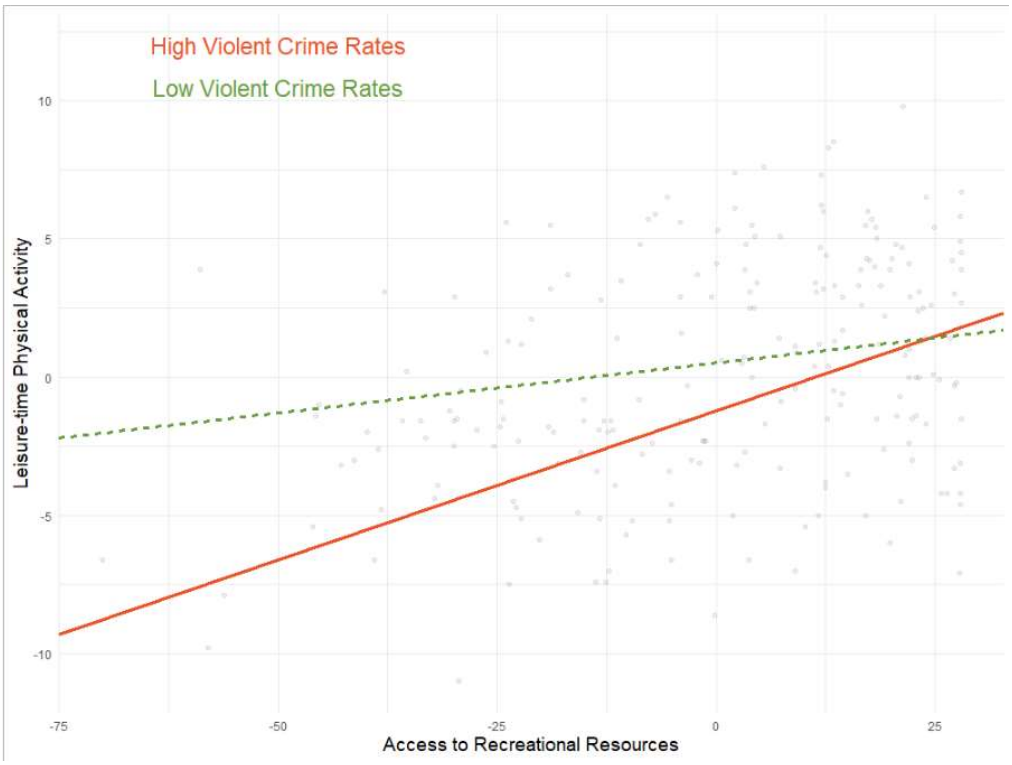


Figure 2

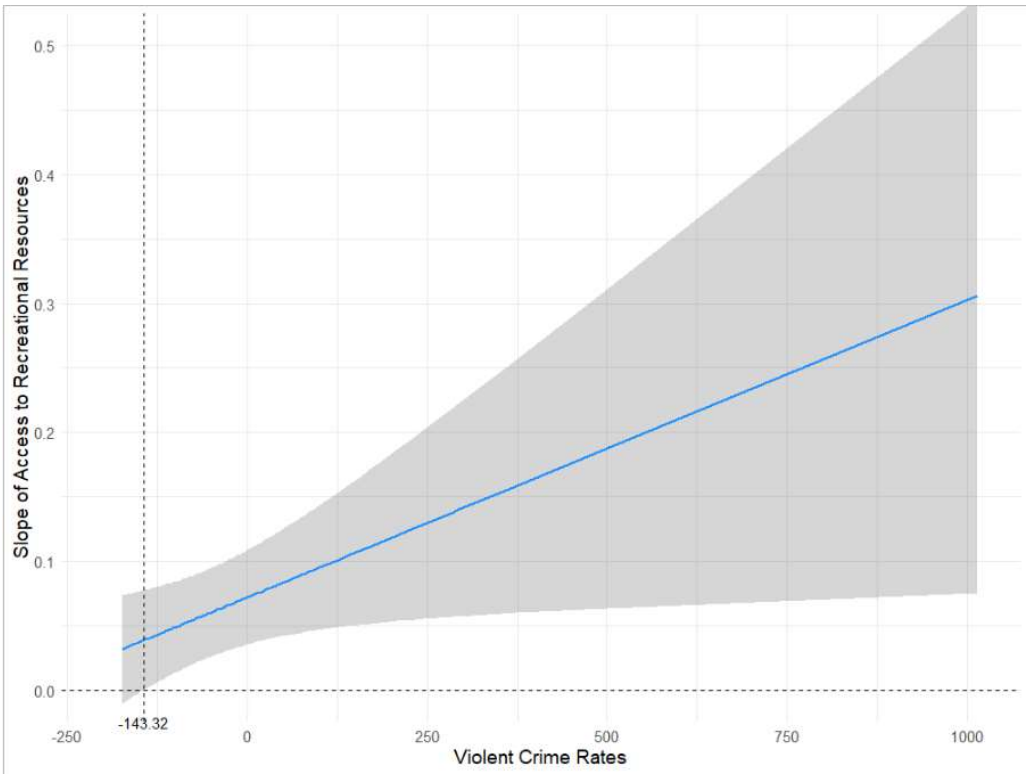
Association Between Access to Recreational Resources and Leisure-time Physical Activity Engagement Moderated by Violent Crime Rates in Northeastern Counties



Note. All variables were mean centered. One standard deviation above the mean indicated high levels of violent crime rates and one standard deviation below the mean indicated low levels of violent crime rates. Simple slopes indicated that counties with high violent crime levels ($b = 0.108$, $p < .001$) greater access to recreational resources was associated with increased LTPA engagement. There was no significant association between access to recreational resources and LTPA engagement at low levels of violent crime rates ($b = 0.036$, $p = .075$).

Figure 3

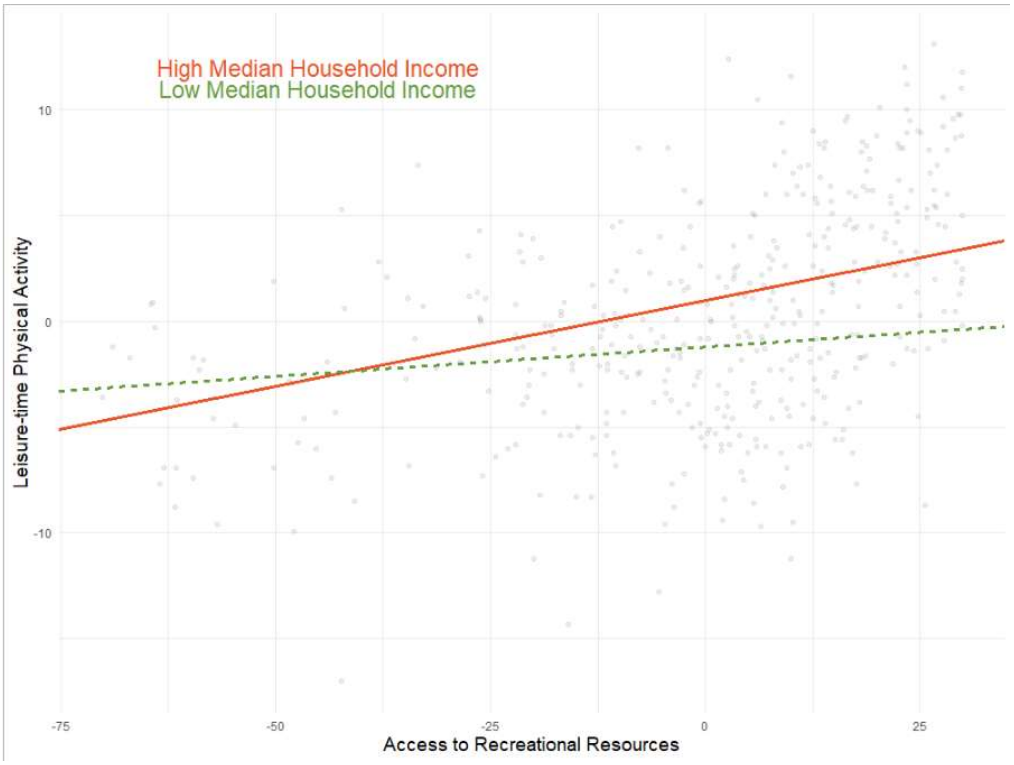
Regions of Significance Examined in the Moderation Analysis Between Access to Recreational Resources and Violent Crime Rates on Leisure-time Physical Activity Engagement in Northeastern Counties



Note. When the value of violent crime rates is between -3287.02 and -143.32, the association between access to recreational resources and LTPA is not statistically significant. Any value outside of this region represents a statistically significant association between access to recreational resources and LTPA. Only observed values in the data are presented.

Figure 4

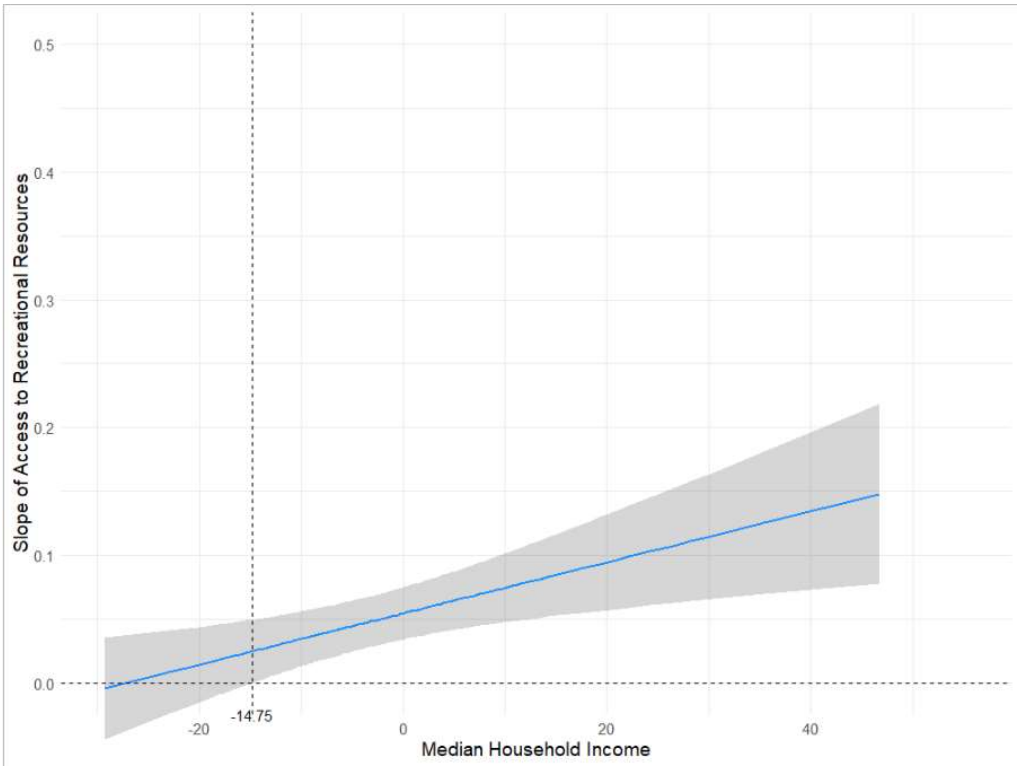
Association Between Access to Recreational Resources and Leisure-time Physical Activity Engagement Moderated by Median Household Income in Western Counties



Note. All variables were mean centered. One standard deviation above the mean indicated high levels of median household income and one standard deviation below the mean indicated low levels of median household income. Simple slopes indicated that counties with high median household incomes ($b = 0.080$, $p < .001$) and low median household incomes ($b = 0.028$, $p = .019$), greater access to recreational resources was associated with increased LTPA engagement.

Figure 5

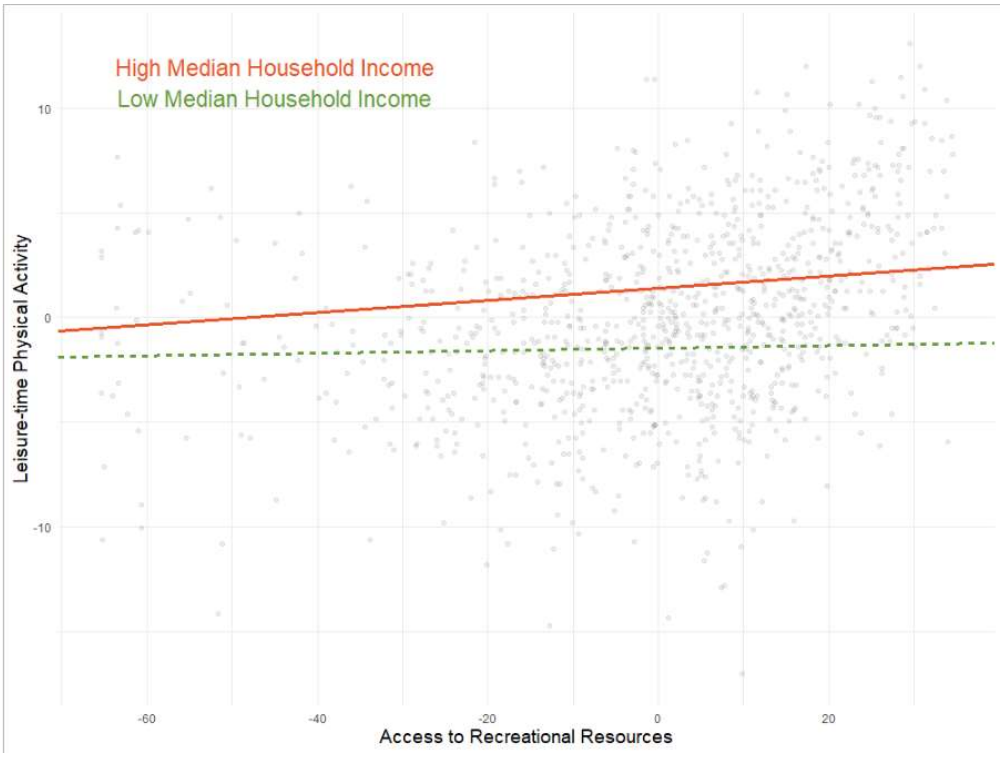
Regions of Significance Examined in the Moderation Analysis Between Access to Recreational Resources and Median Household Income on Leisure-time Physical Activity Engagement in Western Counties



Note. When the value of median household income is between -76.62 and –14.75, the association between access to recreational resources and LTPA is not statistically significant. Any value outside of this region represents a statistically significant association between access to recreational resources and LTPA. Only observed values in the data are presented.

Figure 6

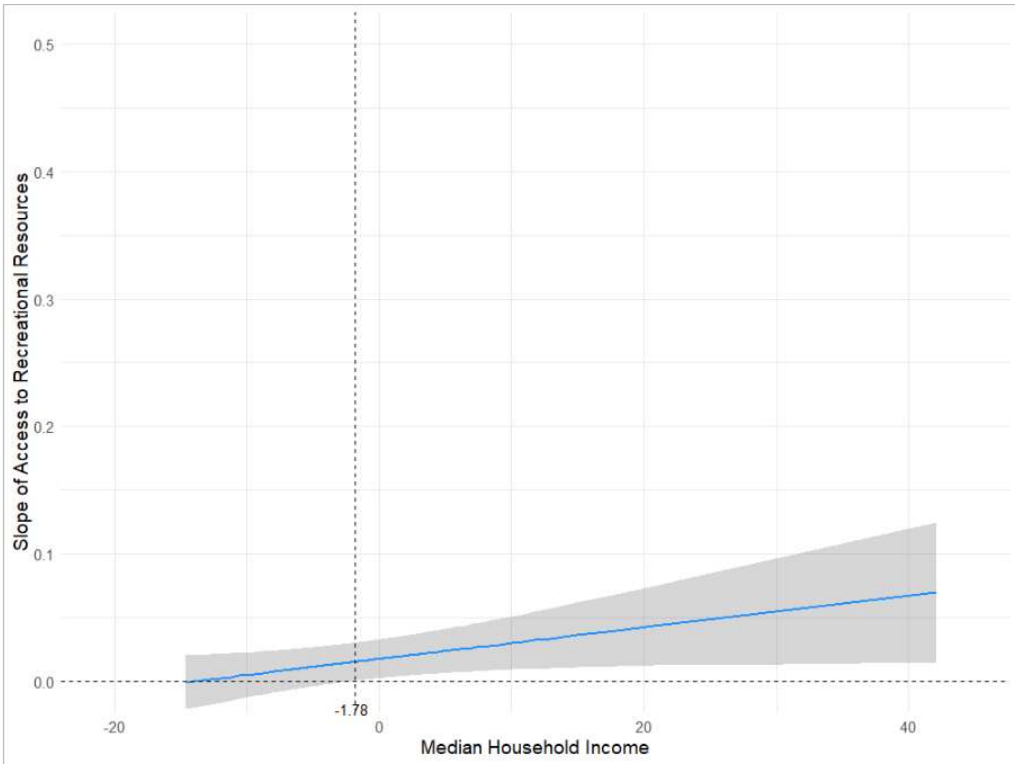
Association Between Access to Recreational Resources and Leisure-time Physical Activity Engagement Moderated by Median Household Income in Midwestern Counties



Note. All variables were mean centered. One standard deviation above the mean indicated high levels of median household income and one standard deviation below the mean indicated low levels of median household income. Simple slopes indicated that counties with high median household incomes (b = 0.029, p = .005), greater access to recreational resources was associated with increased LTPA engagement. There was no significant association between access to recreational resources and LTPA engagement at low median household incomes (b = 0.006, p = .504).

Figure 7

Regions of Significance Examined in the Moderation Analysis Between Access to Recreational Resources and Median Household Income on Leisure-time Physical Activity Engagement in Midwestern Counties



Note. When the value of median household income is between -254.41 and –1.78, the association between access to recreational resources and LTPA is not statistically significant. Any value outside of this region represents a statistically significant association between access to recreational resources and LTPA. Only observed values in the data are presented.

Figure 8

Spatial Distribution of Counties in the Northeast from the Main Effects OLS Regression Residuals

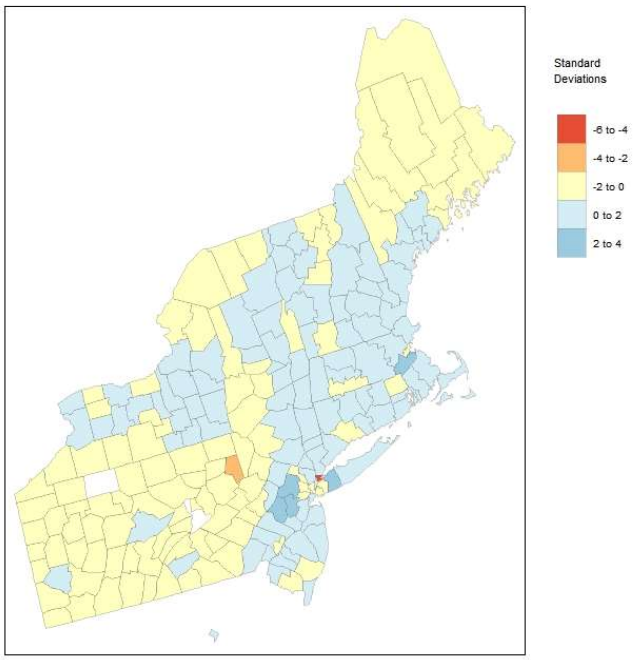


Figure 9

Spatial Distribution of Counties in the South from the Main Effects OLS Regression Residuals

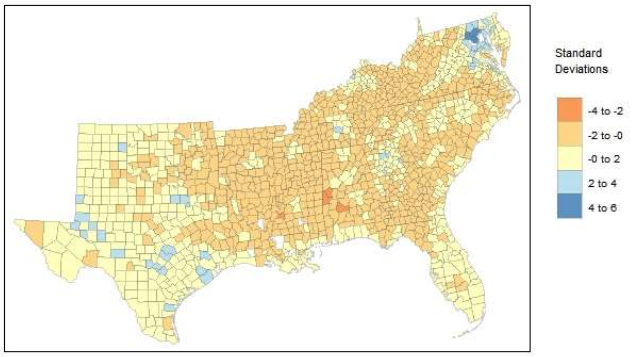


Figure 10

Spatial Distribution of Counties in the West from the Main Effects OLS Regression Residuals

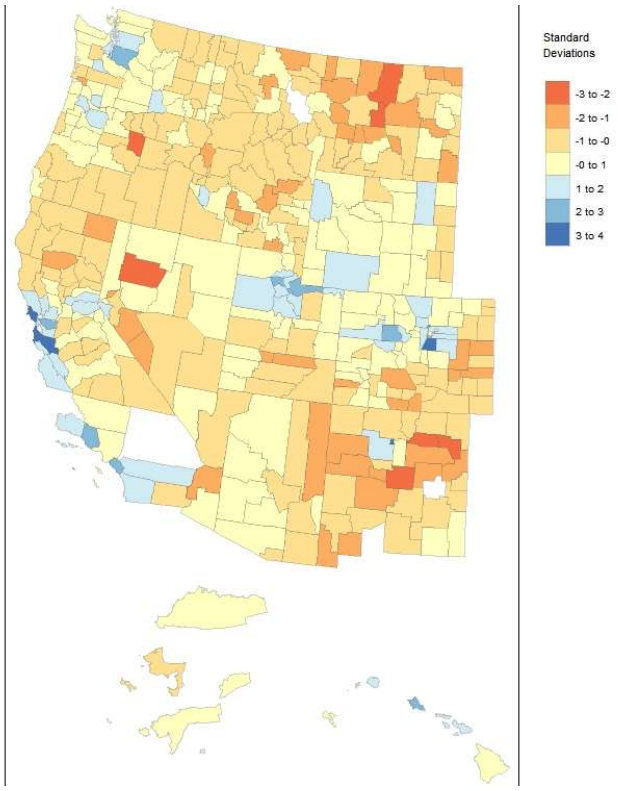
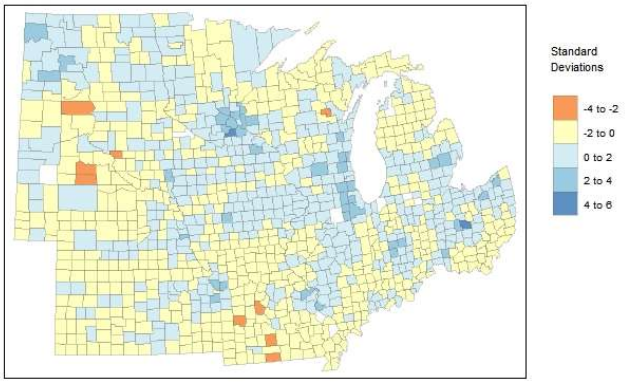


Figure 11

Spatial Distribution of Counties in the Midwest from the Main Effects OLS Regression Residuals



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