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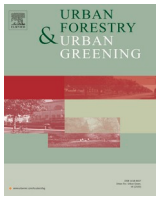

Original article

Not all 'greenness' is equal: Influence of perceived neighborhood environments on psychological well-being in Chicago

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ABSTRACT

Neighborhood greenness is of growing importance to understand the quality of urban life, including outcomes tied to health and well-being. However, all greenness may not lead to the same outcomes in racially and ethnically segregated cities. There are many factors associated with the influence of greenness, including perceptions of the physical and social environments. By using multilevel logistic regression analysis, this study investigated differences in psychological well-being associated with neighborhood greenness, park use frequency, and perceived neighborhood physical and social settings in Chicago, IL. We used individual-level health data of 4517 Chicago respondents in 77 neighborhoods, which were aggregated into three distinct regions of the city and drawn from the 2020 Healthy Chicago Survey (HCS); neighborhood greenness was measured using the Normalized Difference Vegetation Index (NDVI). Results suggest that: (1) greenness was significantly associated with psychological well-being in Chicago's North region but not in the other regions; (2) more frequent park use was associated with psychological well-being in the North region but not in the other regions; (3) neighborhood safety was the strongest predictor of psychological well-being in all three regions of Chicago. This study offers theoretical and practical insights on the need for comprehensive assessment that can help disentangle and differentiate the levels of care and maintenance in urban green spaces. By coupling NDVI with geographic differences, researchers can better capture the complex interplay between different aspects of greenness and urban residents' well-being.

1. Introduction

1.1. Neighborhood greenness and psychological well-being

Over the recent decades, environmental public health discourse has expanded its focus from risk factors to a broader view that includes the health benefits of urban nature and greenery (Gee & Payne-Sturges, 2004; Kowarik, 2018; Lioy, 1990; Shanahan et al., 2015). A growing body of evidence has supported the positive impact of neighborhood greenness—green nature surrounding one's place of residence—on people's psychological health and well-being (Hadavi, 2017; van den Berg et al., 2015; Ward Thompson et al., 2012). Most of the positive associations found in previous studies have been cross-sectional; however, longitudinal studies have added further insight into a

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nature–health pathway, demonstrating that urban residents reported lower psychological distress and improved well-being after moving to greener areas (White et al., 2013).

Stress reduction theory (SRT; Ulrich, 1981; Ulrich et al., 1991) and attention restoration theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995) provide theoretical explanations for how greenness work with respect to recovery from mental fatigue, stress, and negative feelings. SRT posits that exposure to nature has the capacity to reduce stress and negative emotions by activating one's positive affect and aesthetic responses (Ulrich, 1981; Ulrich et al., 1991). According to SRT, urban/man-made settings cannot replicate the positive impacts of natural environments because humans have evolutionarily adapted to recover from stress not in built environments, but in natural environments—areas that have a direct bearing on our survival and well-being (Ulrich, 1983). Psycho-evolutionary connections indicate that simply viewing natural scenes can reduce stress through the automatic, unconsciously triggered emotional responses (Orians and Heerwagen., 1992).

While SRT focuses on nature's role in reducing psychophysiological stress, ART describes the restorative benefits of nature. Urban lifestyles involve various tasks that require effortful cognitive engagement – a process known as directed attention. This involuntary form of attention is considered a finite resource that will be exhausted after prolonged use, eventually resulting in attention fatigue and other mental health issues such as anxiety and distress (Kaplan & Kaplan, 1989; Kaplan, 1995). ART assumes that natural environments encompass "softly fascinating" elements such as clouds, sunsets, and leaves, which allow our directed attention to rest and recover. Spending time in nature enables individuals to psychologically "get away" from the hectic urban life filled with attention-demanding tasks, thus enhancing the restorative experience. ART also integrates the concept of compatibility, which is defined as a "resonance between the natural setting and human inclinations" (Kaplan, 1995, p. 174). A compatible environment helps people engage effectively in natural and social activities that fit their purposes. Natural areas are considered to be highly compatible in that they can easily enable purposeful activities such as walking, wildlife watching, and picnicking.

Both SRT and ART explicate the cognitive and socio-emotional dimensions of human–nature relationships as well as the possible links to psychological well-being. The theories highlight the roles of nature as "restorative" places that can enhance important health outcomes. In urban settings, convenient green spaces provide a spectrum of opportunities for leisure experiences, including physical activities and social gatherings (Gobster, 2001; Nath et al., 2018; White et al., 2017). Many of these nature-based activities are readily accessible, increasing "compatibility" with our intrinsic motivations (Kaplan, 1995). For urban residents, such natural outdoor experiences would be a useful source of contact with nature and relaxation (Birch et al., 2020). Although there are convincing theoretical reasons for the positive impact of green nature on well-being, in practice, there may be other factors that affect one's psychological well-being, such as perceptions of neighborhood and related environments.

1.2. Perceived neighborhood physical and social environment in a racially segregated city

The neighborhood is a place in which individuals spend most of their non-work time, and therefore, the neighborhood context may have a significant influence on residents' everyday experiences and quality of life (Rohe, 2009). As a general rule following from SRT and ART and their associated research, the greener a space, the more likely one would spend time in the space, yet this rule becomes more complex in cities due to residents' perceptions of their neighborhoods (Gubbels et al., 2016).

In historically racially segregated cities, large-scale segregated park systems are prevalent (Kephart, 2022; Rigolon & Németh, 2021). The disparities in perceived access to quality green space across different ethnic/racial groups have been an important topic of scholarly research (Floyd, 1998; Rigolon, 2016). With less vegetation cover, parks, green space, and other nature-based recreational settings, these neighborhoods—that are often communities of color—frequently have unequal access to high-quality urban nature (Boone et al., 2009; Tooke et al., 2010). Previous studies have highlighted the negative effects of perceived racism, safety, low walkability, and lack of maintenance on park usage, including physical activity and socialization (Erickson et al., 2009; Iyer et al., 2020; Johnson et al., 2001; Stodolska et al., 2011). For instance, a person may live close to the neighborhood park but may prefer to spend time in their small patio garden for different social meanings and experiences in the place (Mikels-Carrasco, 2010), such as safety concerns about the neighborhood park (Fernandez et al., 2021; Hughey et al., 2016 ; Groshong et al., 2020).

The historical trend of racial residential segregation has further intensified the unequal allocation of resources in communities of color (Kephart, 2022), resulting in the poorer maintenance of built and natural environments, including neighborhood streets, public squares, nearby parks, and other public places that serve their residents (Suglia et al., 2016). As a consequence, these neighborhood places tend to be poorly managed, which can lead to physical disorders (Hadavi et al., 2021). Wilson and Kelling's (1982) broken windows theory also described that physical signs of neglect and disorder in the neighborhood can encourage further crime and anti-social conduct in the neighborhood, negatively affecting residents' feelings of well-being and safety. This idea is supported by empirical research, which shows that visibly neglected areas have resulted in crime and vandalism, endangering neighborhood health and well-being (Jin et al., 2021).

The effects of the perceived neighborhood environment on psychological well-being have been a topic of interest in recent years (Foo et al., 2015; Gubbels et al., 2016; López-Contreras et al., 2021). Illegal dumping and trash accumulation in vacant neighborhood areas may cause negative emotions such as frustration and despair (Jin et al., 2021). Improved neighborhood aesthetics and safety were significantly associated with lower stress (Henderson et al., 2016). A "walkable" neighborhood environment is also an essential component in determining residents' quality of life (Van Cauwenberg et al., 2016).

Perceived social environments surrounding the neighborhood comprises "the relationships, groups, and social processes that exist between individuals who live in a neighborhood" (Suglia et al., 2016, p. 207). These involve feelings of belonging, mutual trust among neighbors to impact the community, and other types of social interactions such as social supports (Jennings & Bamkole, 2019). Enhanced social belongingness could positively affect residents' sense of psychological well-being (López-Contreras et al., 2021), whereas less frequent social contacts and social supports worsened health and well-being (Ruijsbroek et al., 2017).

1.3. Measuring neighborhood greenness

The consistent measurement of urban green spaces has been challenged by the multiplicity of greenness concepts and vegetation characteristics. Previous studies on "greenness" have posed important methodological questions regarding how to conceptualize and measure greenness. Fundamental methodological considerations in linking greenness with health and well-being have primarily focused on the spatial scales and operational definitions of greenness.

Labib et al. (2020) introduced a variety of spatial scales discussed in urban environmental health literature, including personal (e.g., immediate surroundings of the human body), neighborhood (e.g., administrative zones), and region/district scales (e.g., broad geographic areas that comprise several neighborhoods). These multiple geographic scales are not just about physical scales but also reflect the study population and their various relationships with the place at multiple levels (Stewart et al., 2013). For the personal scale, buffer distances from residences are defined to assess one's exposure to greenness (e.g., a 300-meter radial

buffer around each residence) and are determined on walkability and everyday usage, in which people engage in physical activities and interact with one another (Annerstedt van den Bosch et al., 2016). Measuring greenness in a broader buffer from one's residence could be helpful given that people might walk longer distances or have available transportation to the green areas (Rigolon et al., 2021). This decision may also be influenced by each study population and setting; for instance, a smaller buffer size would be preferable when studying children and the elderly as they are not able to drive vehicles, limiting access to parks and green spaces in remote areas (Sikorska et al., 2020). Of the many spatial scales, the neighborhood scale is most frequently used to measure "greenness" (Western Australian Planning Commission., 2015) with neighborhood greenness being the notation of the unit of analysis (Leslie et al., 2010).

The Normalized Difference Vegetation Index (NDVI) is the most widely used and validated metric for quantifying "greenness" across various study settings (Rhew et al., 2011). NDVI is calculated as the difference between visible red (Red) and near-infrared reflectance (NIR) divided by the total using the following formula: NDVI = (NIR – Red) / (NIR + Red). The formula yields a value that ranges from − 1 to 1. Higher values suggest a greater density of green vegetation, and negative values indicate water bodies and snow cover. Spatial analytic approaches have been adapted in urban environmental justice scholarship (Nesbitt et al., 2018). Previous research has demonstrated the unequal distribution of "greenness" among different socio-demographic groups (Rigolon et al., 2018), particularly in urban areas, where communities of poverty and color are physically and socially segregated from those of wealth (Rohe, 2009). Nonetheless, regional differences of a greenness–health pathway in segregated cities are typically given less attention.

2. Study context

Chicago, Illinois, remains one of the most segregated metropolitan areas (Moore, 2019), with a diverse population of 2746,388 as of 2020 that consists of 33% non-Hispanic White, 29% Black or African American, 29% Hispanic or Latino, 7% Asian, and 5% two or more races in 2020 (U.S. Census Bureau., 2020). Despite being one of the most diverse cities in the country, racial residential segregation has led to significant consequences for health disparities (Orsi et al., 2010). The Healthy Chicago framework acknowledged the widening life expectancy gap in the city, thus addressing the strategies to close the gap and ensure healthy living for all residents (Chicago Department of Public Health., 2020). Despite national and local attempts to eliminate regional disparities, Chicago has undergone shrinkage problems, vacancy, abandonment, and blight in particular neighborhoods while others growing wealthier, exacerbating the city's deeply ingrained divisions (Butler, 2016).

Chicago has demonstrated a long-standing spatial segregation of race and class (Hagan et al., 2022). To understand these regional differences, 77 community areas were clustered into three regions (North, West, and South) (See Fig. 1). The groupings of regions were based upon the distinct histories of development of the north, west, and south sides of the city, in part, due to the natural boundary of the Chicago River (Cronon, 1992). These differences in development led to distinguishable settlement patterns and racial divides (McCammack, 2017). The distinct

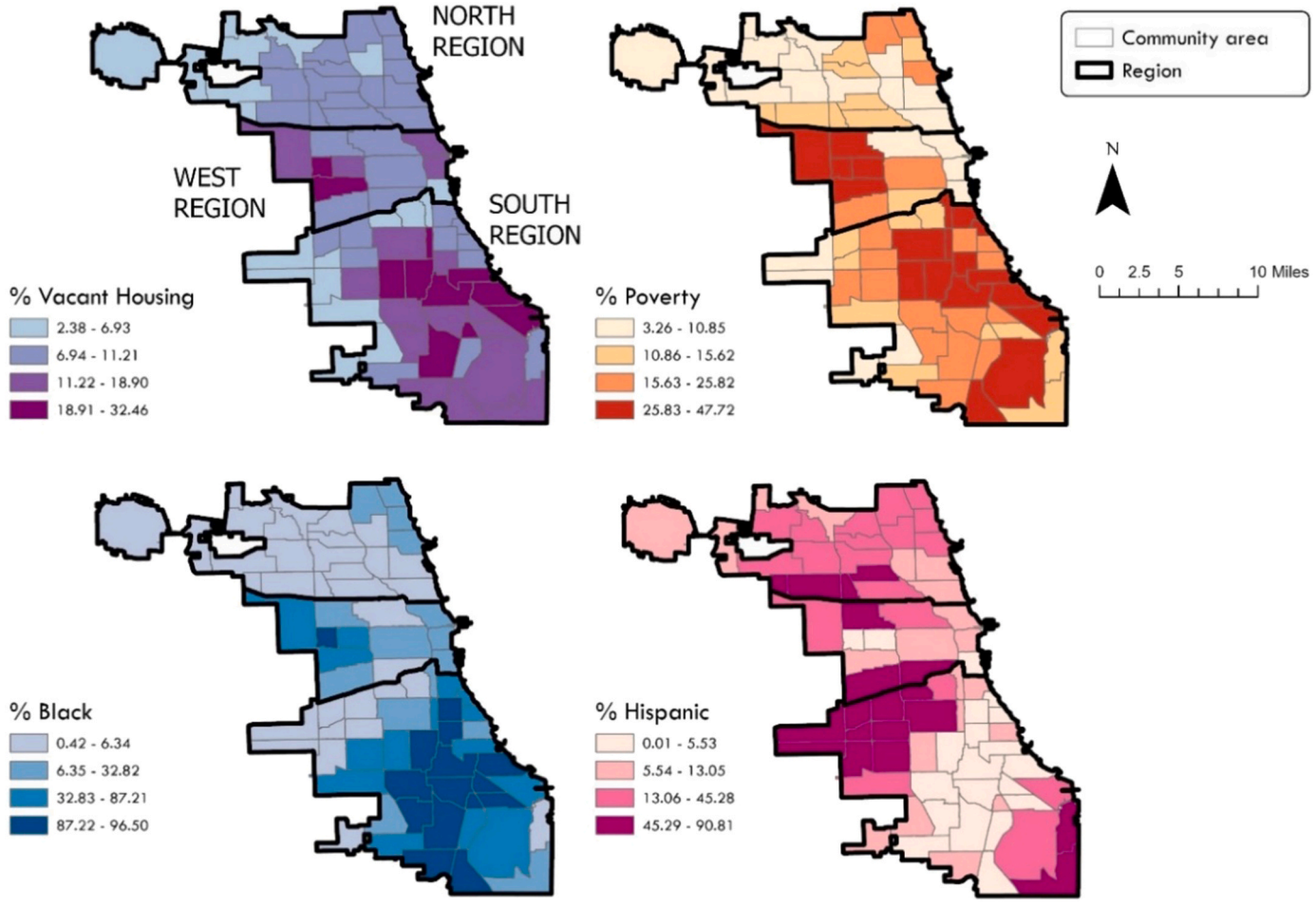

Fig. 1. Vacant housing rates, poverty rates, % Black and Hispanic populations in Chicago, IL
Source: Authors' analysis of data from the American Community Survey (ACS), 2016–2020.

histories are evident today in the differences in socio-demographic characteristics that exist between the three regions. As illustrated in Fig. 1, there is a significant overlap between geographic areas with high percentages of Black and Hispanic residents and areas with high proportions of abandoned properties and poverty rates. There are disparities in residential vacancy and poverty between neighborhoods in the South and West regions and those on the North. Such intersections of poverty and race highlight the complicated situations connected with urban blight, which provides the justification for the study's analysis at a regional scale.

The study addresses a gap in the literature to assess the impact of greenness on subjective well-being along with consideration of perceptions of neighborhood environments and park accessibility. Specifically, the study examines the extent of relationships between neighborhood greenness measured by NDVI, park use frequency, perceived physical and social attributes of the neighborhood, and psychological well-being of residents within the 77 neighborhoods of Chicago, IL. The study investigates how this relationship differs across three regions of the city (North, West, and South). Specifically, we hypothesized that:

1) Higher levels of greenness are positively associated with higher levels of psychological well-being (Hypothesis 1).
2) More frequent park use is positively associated with psychological well-being (Hypothesis 2).
3) Perceived neighborhood physical and social environment are significant predictors of psychological well-being (Hypothesis 3).

3. Methods

The study used two data sources to explore the psychological distress level of Chicago's residents associated with their neighborhood greenness, park use frequency, and perceived neighborhood physical and social environment. Greenness exposure was quantified using satellite remote sensing data at the neighborhood scale, with the neighborhood defined as the community areas of the city (Voorhees Center., 2014). The City of Chicago is divided into 77 community areas, with community areas comparable in size to census tracks nested within regions and referred to as neighborhoods. To assess psychological well-being, park use frequency, neighborhood physical and social environment, and other socioeconomic characteristics, the study used data from the 2020 Healthy Chicago Survey (HCS), an annual survey conducted by the Chicago Department of Public Health. Between July 17 and November 11, 2020, the HCS collected health-related information on Chicagoans aged 18 or older. To address the historical under-representation of people of color, the HCS adopted an address-based sampling frame to randomly draw the sample from 77 neighborhoods. There were 4517 completed surveys collected from 77 neighborhoods (80.8% via web and 19.2% via paper). The methodology report included details on sampling strategies, survey design, instrumentation, and data collection procedures (RTI International., 2020).

3.1. Measures

Table 1 contains the variables assessed in the study with highlights of the measures.

3.1.1. Psychological well-being

The Kessler Psychological Distress Scale (K6) was used to measure psychological well-being in previous studies (Callanan et al., 2021; Xu et al., 2019). Respondents were asked to indicate how frequently they felt the following symptoms during the past 30 days: hopeless, restless, depressed, everything an effort, and worthless (Kessler et al., 2002). Each item included five options ranging from 0 (none of the time) to 4 (all of the time), which are then summed for a total score of 0–24. A K6 score of 8 or greater represented having mild and serious psychological distress, whereas a K6 score of 0–7 indicates zero to low distress

Table 1
Psychological well-being, neighborhood greenness, neighborhood physical and social environment related variables and questionnaire items.

Variables	Questionnaire questions/unit
Psychological well-being	
The Kessler Psychological Distress Scale	During the past 30 days, how often did you feel…
Nervous	
Hopeless	
Restless	
Depressed	
Everything an effort	
Worthless	
Neighborhood greenness	Normalized difference vegetation index (NDVI, −1–1)
Park use frequency	In the past 12 months, how often did you or someone in your household use the parks, playgrounds and sport fields in your neighborhood?
Perceived neighborhood PE	
Sidewalk maintenance	The sidewalks in my neighborhood are well-maintained (paved, even and not a lot of cracks).
Free from litter	My neighborhood is generally free from litter.
Interesting thing to see	There are many interesting things to look at while walking, scooting, or rolling in my neighborhood.
Walkability	It is easy to walk, scoot, or roll to a transit stop (bus, train) from my home.
Neighborhood safety	Do you feel safe in your neighborhood?
Perceived neighborhood SE	
Social belongingness	Would you say that you really feel part of your neighborhood?
The number of people to ask for help	About how many people in your neighborhood do you know well enough to ask for help if you needed it?
Social contacts	Would you say that you regularly stop and talk with people in your neighborhood?
Sense of efficacy	To what extent do you feel like you and your neighbors have the ability to impact your community?

Note. PE: physical environment; SE: social environment.

(Furukawa et al., 2008). Like other similar urban studies that used K6 score to measure psychological distress (Ha et al., 2022), the distribution of a continuous outcome variable (psychological distress) was too polarized to allow linear regression (SD = 5.02). Thus, these responses were re-coded into a binary variable (Sommet & Morselli, 2017), with 0 indicating no psychological distress and 1 indicating psychological distress following previous studies (Rajan & Cherian, 2021).

3.1.2. Greenness

was assessed using the Normalized Difference Vegetation Index (NDVI) data from the Moderate-resolution Imagining Spectroradiometer (MODIS) onboard NASA's Terra satellite (Didan, 2015). We used cloud-free NDVI-MODIS data for the City of Chicago collected during summer months (July and August 2020). The choice of summer months was based on greater availability of greenness during this period in Chicago. The collected NDVI data have a resolution of 250 m and were generated over a 16-day period. Fig. 2 illustrates neighborhood greenness measured by NDVI-MODS in the City of Chicago, with darker areas indicating higher levels of greenness. After creating the NDVI-MODIS map (Fig. 2), the mean NDVI values for each Chicago neighborhood were computed using ArcGIS Pro (v. 10.8). Neighborhood greenness differed among 77 different neighborhoods, with the mean NDVI values ranging from 0.21 to 0.57.

3.1.3. Park use frequency

was measured by a single item that assessed the stated frequency with which respondents used the parks, playgrounds, and sport fields in their neighborhoods in the past 12 months (1 = never to 5 = once a week or more).

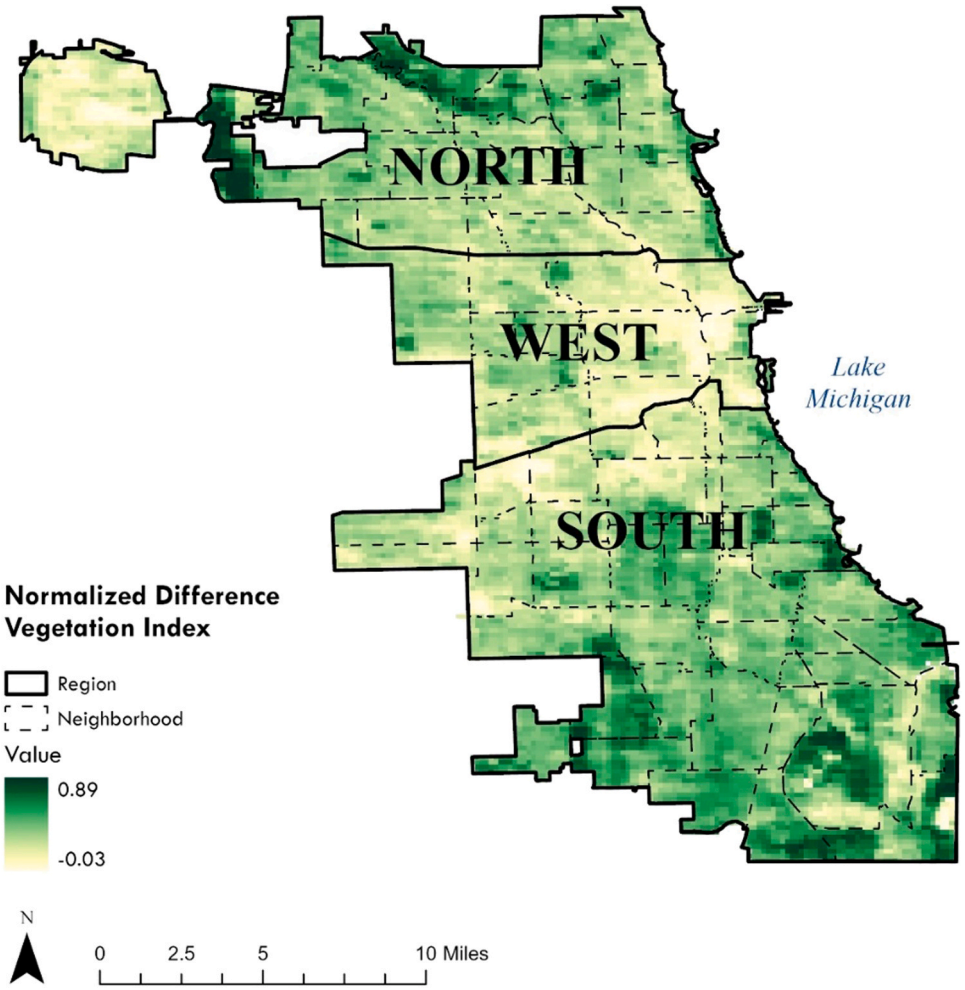

Fig. 2. The spatial variation in the value of MODIS-NDVI in the City of Chicago.
Source: Authors' analysis of data from the American Community Survey (ACS), 2016–2020.

3.1.4. Perceived neighborhood physical environment, social environment, and demographic factors

were also assessed using the HCS survey. Perception of neighborhood physical environment was measured by five survey items related to neighborhood aesthetics ("The sidewalks in my neighborhood are well-maintained (paved, even and not a lot of cracks)," "My neighborhood is generally free from litter," "There are many interesting things to look at while walking, scooting, or rolling in my neighborhood"), walkability ("It is easy to walk, scoot, or roll to a transit stop (bus, train) from my home"), and neighborhood safety ("Do you feel safe in your neighborhood?"). Perception of neighborhood social environment was measured by four survey items regarding social belongingness ("Would you say that you really feel part of your neighborhood?"), the number of people for the participants to be able to ask for help ("About how many people in your neighborhood do you know well enough to ask for help if you needed it?"), social contacts ("Would you say that you regularly stop and talk with people in your neighborhood?"), and sense of efficacy to impact their community ("To what extent do you feel like you and your neighbors have the ability to impact your community?"). The five-point Likert scale response categories ranged from 1 (strongly agree) to 5 (strongly disagree) with 3 (neither disagree nor agree) as the center point. Internal consistency (α) was 0.79 for perceived neighborhood physical environment and 0.73 for perceived neighborhood social environment scales. Demographic factors including gender, race/ethnicity, and income level were also assessed.

3.2. Statistical analysis

3.2.1. Descriptive analysis

We performed all statistical analyses in SPSS (v. 26.0). Following the methodology report (RTI International., 2020), survey weights were applied to ensure results were representative of the general Chicago population. Variance inflation factor (VIF) was used to test the multicollinearity among assessed variables, and none of the variables were dropped (all VIF < 1.7). Descriptive statistics were used to understand the characteristics of respondents by the key variables. Then, the weighted percentage of the survey respondents experiencing psychological distress were described in relation to other sample characteristics.

3.2.2. Multilevel logistic modeling

We employed a multilevel logistic model to analyze data in which neighborhood greenness was measured at neighborhood scale (77 neighborhoods), whereas other variables were examined at the individual level (4517 individuals) nested within the neighborhoods. The following formula was used to predict the outcome variable of psychological well-being by the independent variables:

$$\begin{aligned} logit_i = {} & \beta_0 + \beta_1 greenness_j + \beta_2 parkuse_{ij} + \beta_3 gender_{ij} + \beta_4 raceth_{ij} \\ & + \beta_5 income_{ij} + \beta_6 sidewalk_{ij} + \beta_7 walkability_{ij} + \beta_8 litter_{ij} \\ & + \beta_9 interesting_{ij} + \beta_{10} safety_{ij} + \beta_{11} belonging_{ij} + \beta_{12} help_{ij} \\ & + \beta_{13} contact_{ij} + \beta_{14} efficacy_{ij} + \mu_{0j} \end{aligned}$$

<where i represents the individual-level units, j represents the neighborhood-level units, $\beta_0 - \beta_{14}$ are coefficients of independent variables, and μ_{oj} represents the random intercepts at the neighborhood level> .

3.2.3. Spatial autocorrelation and weighting

After examining the Moran's I statistic for the key variable, we identified spatial autocorrelation in the greenness variable and thus proceeded to construct a spatial weighting matrix *W*. Using the contiguity edges and corners approach, known as Queen's Case, polygons that shared an edge or corner were considered as neighbors in the spatial weighting matrix (Ali et al., 2022; Getis & Aldstadt, 2010), which allowed us to capture the spatial influences and interactions between neighboring areas in relation to neighborhood greenness. Row standardization was applied to ensure that the weights assigned to the neighboring polygons were proportionally adjusted to limit the imposed aggregation scheme of neighborhoods. Once the spatial weighting matrix was constructed, we incorporated it into the regression models, thus addressing the issue of spatial autocorrelation present in the greenness variable.

Finally, we identified three multilevel logistic models to understand the similarities and differences in three regions, namely North (Model 1), West (Model 2), and South (Model 3), in the influence of neighborhood-level greenness, and individuals' park use frequency, perceptions of their neighborhood physical and social environments on the likelihood of psychological distress. These models represent the final models for each region and provide insights into the unique characteristics and effects within each area.

We reported odds ratios (OR) and 95% confidence intervals (CI) for each model. OR greater than 1 indicate increased odds of having psychological distress compared to the reference group. Conversely, OR less than 1 indicate decreased odds of having psychological distress compared to the reference group. The models included all covariates, and the analysis was adjusted for gender, race/ethnicity, income, and spatial weights.

4. Results

A comparison of the demographic characteristics of HCS participants with the general Chicago population (see Table 2) supports that the sample was representative of the Chicago general population. For the sample, women comprised approximately 52%, and the median household income was $50,000. Respondents were 34.8% Non-Hispanic (NH) White, 28.1% NH Black/African American, 28.3% Hispanic, and 8.8% were NH Other (i.e., Asian, American.

Indian or Alaska Native, and Native Hawaiian and Pacific Islander).

Overall, 27.1% of the sample reported psychological distress (K6 score > 8). Low park use was observed among Chicago residents, with approximately 40% of survey respondents stating that they either never use a park (22.1%), or use a park a few times a year (17.1%).

Table 3 displays the percentages of respondents reporting psychological distress in relation to other variables.

The prevalence of psychological distress appeared to be approximately 7% greater for respondents who use a park a few times a year (32.0%) compared to those who use a park at least once a month (25.2%) and several times a month (25.5%). While lower prevalence of psychological distress was observed with those living in a neighborhood reporting well-maintained sidewalks, interesting things to see, and is free from litter and walkable. Neighborhood safety showed the most distinct variation among the physical environment factors; 44% of those who reported their neighborhood was "mostly not safe" had psychological distress, compared to 21.5% of those who reported their neighborhood to be "safe all of the time." In addition, the results revealed differences in the prevalence of psychological distress with respect to social belongingness, the number of people to ask for help, social contacts, and a sense of efficacy. Females, NH Asian/Pacific Islander and

Table 2
Demographic characteristics of HCS participants and Chicago population.

	HCS Participants[1]	City of Chicago
Percent female	51.7%	51.4%
Percent NH White	34.8%	33.3%
Percent NH Black/African American	28.1%	29.2%
Percent Hispanic/Latino	28.3%	28.6%
Median household income	$50,000	$62,097

Note: HCS: Healthy Chicago Survey; NH: Non-Hispanic; All data are from 2020.
[1]Weighted demographic characteristics.

Table 3
Sample percentage reporting psychological distress, as defined by scores > 7 out of 24 on the Kessler 6 Psychological Distress Scale.

Variables	Weighted % psychological distress
Neighborhood level (n_j= 77)	
Neighborhood greenness (NDVI-mean)	
Individual level (n_i = 4517)	
Park use frequency	
Never	26.7
A few times a year	32.0
At least once a month	25.2
Several times a month	25.5
Once a week or more	26.4
Perceived neighborhood PE	
Sidewalk maintenance	
Disagree	30.9
Agree	23.7
Free from litter	
Disagree	31.0
Agree	22.7
Interesting thing to see	
Disagree	30.4
Agree	23.9
Walkability	
Disagree	37.6
Agree	24.6
Neighborhood safety	
No, mostly not (safe)	44.0
Sometimes	30.0
Yes, most of the time	24.0
Yes, all of the time	21.5
Perceived neighborhood SE	
Social belongingness	
Disagree	32.4
Agree	21.0
The number of people to ask for help	
None	33.5
More than 1	25.1
Social contacts	
Disagree	28.7
Agree	24.8
Sense of efficacy to impact the community	
Not at all	33.2
A little	30.1
Somewhat	24.1
A great extent	22.1
Socioeconomic factors	
Gender	
Male	24.9
Female	28.6
Race	
NH White	27.5
NH Black/African American	23.5
Hispanic/Latino	29.3
NH Asian/Pacific Islander and Other	30.2
Annual income	
0–25k+	32.8
25–50k	27.3
50–75k	26.8
75–100k	27.6
100k+	22.6

Note. PE: physical environment; SE: social environment; NH: Non-Hispanic

Other, and those with annual household incomes of less than $25,000 had a higher prevalence of psychological distress than other counterparts.

The results of the multilevel logistic models are shown in Table 4. The North and South regions had high intraclass correlation coefficients (ICC), 0.10 and 0.15 respectively, implying that 10% of the variance in psychological distress can be explained by the neighborhood effect in the North region and 15% in the South region. The West region had the lowest ICC (0.05).

Table 4
Multilevel logistic regression models of neighborhood greenness, park use frequency, and perceived neighborhood physical and social environments on psychological distress by region.

Variables	Model 1 North	Model 2 West	Model 3 South
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Group level			
Neighborhood greenness	0.016 (0.000, 0.959)*	1.940 (0.027, 14.062)	0.620 (0.038, 10.002)
Individual level			
Park uses frequency	0.971 (0.967, 0.975)***	1.014 (1.009, 1.019)***	1.000 (0.996, 1.004)
Perceived neighborhood PE			
Sidewalk not well-maintained	1.153 (1.139, 1.168)***	1.296 (1.274, 1.318)***	0.998 (0.984, 1.013)
Poor walkability	1.244 (1.225, 1.264)***	2.470 (2.424, 2.517)***	1.108 (1.092, 1.125)***
Presence of litter	1.088 (1.074, 1.102)***	0.840 (0.825, 0.856)***	1.090 (1.074, 1.107)***
Lack of interesting things to see	1.249 (1.232, 1.266)***	0.738 (0.724, 0.752)***	1.264 (1.244, 1.284)***
Neighborhood safety	0.879 (0.871, 0.886)***	0.675 (0.668, 0.682)***	0.670 (0.664, 0.676)***
Perceived neighborhood SE			
Lack of social belongingness	1.448 (1.430, 1.466)***	1.623 (1.594, 1.651)***	1.489 (1.467, 1.511)***
The number of people to ask for help			
More than 1	1.000	1.000	1.000
None	1.403 (1.384, 1.423)***	1.369 (1.348, 1.391)***	1.629 (1.606, 1.653)***
No regular social contacts	0.872 (0.861, 0.883)***	0.637 (0.627, 0.648)***	0.886 (0.874, 0.898)***
Sense of efficacy	0.771 (0.766, 0.776)***	1.019 (1.010, 1.027)***	1.040 (1.032, 1.047)***
Demographic factors			
Female (ref: Male)	1.198 (1.185, 1.211)***	1.175 (1.158, 1.191)***	1.366 (1.349, 1.383)***
Race (ref: NH White)			
NH Black/African American	0.422 (0.410, 0.434)***	0.387 (0.377, 0.397)***	0.618 (0.603, 0.633)***
Hispanic/Latino	0.895 (0.882, 0.908)***	0.845 (0.825, 0.865)***	0.867 (0.848, 0.886)***
NH Asian/Pacific Islander and Other	0.982 (0.965, 0.999)	1.083 (1.056, 1.111)***	0.744 (0.721, 0.768)***
Annual income			
100k+	1.000	1.000	1.000
75–100k	1.458 (1.433, 1.483)***	1.209 (1.180, 1.240)***	1.225 (1.191, 1.260)***
50–75k	1.271 (1.249, 1.293)***	1.995 (1.943, 2.048)***	1.074 (1.046, 1.102)***
25–50k	1.130 (1.111, 1.149)***	1.905 (1.858, 1.952)***	1.413 (1.380, 1.447)***
0–25k+	1.831 (1.800, 1.863)***	1.787 (1.748, 1.827)***	2.063 (2.018, 2.109)***
N	1633	1027	1857
AIC	3679207.219	2141074.489	3227020.586
ICC	0.10	0.05	0.15

Note. Multilevel logistic regression model was used (ref = no psychological distress). Models adjusted for spatial autocorrelation; PE: physical environment; SE: social environment; NH: Non-Hispanic; AIC: Aikaike information criterion; ICC: Intraclass correlation coefficient. * $p < 0.05$, * ** $p < 0.001$.

A primary finding was that more greenness was associated with less psychological distress in the North region (OR: 0.016, 95% CI: 0.000–0.959); yet there was a lack of evidence of an effect of neighborhood greenness on psychological distress in the West and South regions (Hypothesis 1). Additionally, we found that more frequent park use was associated with less psychological distress in the North region (OR: 0.971, 95% CI: 0.967–0.975), whereas park use frequency was not associated with psychological distress in the South region (Hypothesis 2). Increased park use was associated with increased psychological distress in the West region, but the observed association was not substantial (OR: 1.014, 95% CI: 1.009–1.019).

Results showed that regional variation was not substantial in the associations between perceived neighborhood environments and psychological distress. In all three regions, perceptions of both the physical and social settings of one's neighborhood were significantly linked to the likelihood of reporting psychological distress (Hypothesis 3). In the North region, for example, the high odds of psychological distress were associated with individuals' perceptions of not well-maintained sidewalks (OR: 1.153, 95% CI: 1.139–1.168), poor walkability (OR: 1.244, 95% CI: 1.225–1.264), presence of litter (OR: 1.088, 95% CI: 1.074–1.102), and the lack of interesting things to see (OR: 1.249, 95% CI: 1.235–1.269). Importantly, perceived neighborhood safety was among the strongest predictors of psychological distress in all three regions, and this relationship was particularly pronounced in the South region (OR: 0.670, 95% CI: 0.664–0.676). In the North region, sense of efficacy emerged as the strongest predictor of psychological distress (OR: 0.771, 95% CI: 0.766–0.776). Unexpectedly, across all three regions, respondents having no regular social contacts with their neighbors had lower odds of having psychological distress than their respective reference groups.

Females were more likely than males to experience psychological distress across all three regions. Also, NH Black and Hispanic/Latino were less likely to experience psychological distress than NH White residents in all three regions. In the North and South regions, the lowest annual income group of less than $25,000 had the highest odds of psychological distress, whereas in the West regions, middle-income groups ($50,000–$75,000) were at the highest odds of psychological distress (OR: 1.995, 95% CI: 1.943–2.048).

5. Discussion

Neighborhood greenness is increasingly being explored as a predictor of psychological well-being demonstrating general support for a nature-health pathway (Hadavi, 2017; van den Berg et al., 2015; Ward Thompson et al., 2012). Prior theoretical and empirical research has provided explanations for the restorative qualities of greenness for attention and mood, suggesting that merely being in nature or viewing nature enhances mental health (Kaplan, 1995). Thus, "greenness" is assumed to be a beneficial environmental factor that improves health by providing restorative experience and opportunities for physical activities and social interactions (Peters et al., 2010). However, very few studies examined how this relationship may differ by regions of a city that vary on greenness as well as other environmental and social factors. The regional scale is useful to investigate a group of communities that share similar cultural and historical backgrounds to emphasize historical changes and their implications at the regional level (Stewart and Evans., 2021).

The study revealed different impacts of greenness on psychological well-being across different regions of the diverse metropolitan area of Chicago, Illinois. First, greenness in the South and West regions did not exhibit any effects on psychological well-being, whereas greenness positively predicted psychological well-being in the North region of Chicago (Hypothesis 1). The results may be due to the average-to-high level of greenness in the South and West regions of Chicago. In addition, the use of NDVI may not be an optimal measurement for the types and characteristics of greenness that lowers stress levels (Rugel et al.,

2017). In the South and West regions of Chicago, vacant lots with high levels of greenness often imply an unkempt lot, hazard trees, and opportunistic plants that are unlikely to provide residents with perceived social and health benefits that otherwise would flow from groomed natural features (Berland et al., 2020). These neglected lots, with their poorly maintained vegetation, are considered symbols of neighborhood blight. In other words, the green spaces of the South and West are often low quality and blighted, leading to different responses compared to the well-maintained green spaces in the North region reflecting groomed nature. NDVI is directed at estimating the quantities (or levels) of greenness and thus not suitable for distinguishing across the quality of greenness (e.g., weedy vs groomed). The neighborhoods of Chicago may be a context in which *quantity* and *quality* of greenness need to be disentangled and suggests that NDVI needs coupling with assessment tools to distinguish levels of care (Gobster et al., 2020).

Second, analyses highlight regional differences in the associations between park use frequency and psychological well-being. More frequent park use was associated with psychological well-being in the North region but not in other regions (Hypothesis 2). As suggested by Kaplan (1995), "greenness" could become a place of restoration and healing when people can engage in activities that are "compatible" with their purposes, intentions, and inclinations. In historically marginalized neighborhoods in the South and West sides of Chicago, however, parks may not fulfill as leisure and recreation resources due to barriers such as the presence of gangs, fear of discrimination, safety concerns, as well as poor maintenance of the parks (Fernandez & Witt, 2013; Sreetheran & van den Bosch, 2014).

We also found surprisingly low park use among Chicago residents. Given that 98% of Chicago residents reside within a 10-minute walk of a park (Trust for Public Land., 2021), such physical access is not the dominant factor affecting park use. In addition, urban parks may not be the only source of nature contact for Chicago residents (Jeong et al., 2021). Rather, areas to "get away" from urban stress may take forms of community gardens, private yards, and street gardens that provide therapeutic benefits (Jo et al., 2022; Soga et al., 2017). Johnson and Glover's (2013) analysis reflects the need to broaden the conceptualization of what functions as urban green space and identifies ownership and accessibility as being relevant factors in determining the impact of the space on community life.

Our study also brought a new lens to the research of psychological well-being by simultaneously investigating neighborhood greenness and perceived neighborhood environments. Similar to previous study findings (Bedimo-Rung et al., 2005; Lovejoy et al., 2010), residents' perceptions of neighborhood safety and aesthetics as well as walkability were important factors that influenced their psychological well-being (Hypothesis 3). Residents' perceptions of neighborhood safety were among the strongest predictors of psychological well-being across all three regions in Chicago. Unlike other social factors positively affecting psychological well-being, however, those who have more frequent social contacts with neighbors were more likely to have psychological distress. As the 2020 HCS only asked participants if they regularly talked to other individuals in their neighborhood, we have no further information concerning whether the social contact was a source of positive or negative affect. As suggested by Rook (1984), there could be negative aspects of social contacts, such as criticism and violation of privacy, which might be detrimental to one's psychological well-being.

To the best of our knowledge, this is the first study to examine regional differences in the effect of greenness on psychological well-being in a racially and ethnically segregated urban area. The study has added evidence that supports different impacts of greenness in accordance with the region's social and historical contexts. As limitations, we measured the amount, not the quality of greenness. This study suggests a need to go beyond quantity (Wolch et al., 2014) by examining various dimensions of greenness linked to perceptions of quality and social meanings. A policy implication tied to public health is related to the presence of street trees and visible green spaces as having potential to enhance psychological well-being. Although a common policy directive from this literature is to increase the level of greenness of urban neighborhoods (Wolch et al., 2014), evidence that quality of greenness matters would temper this directive with concerns for nature that is groomed, maintained, and reflects "cues for care" (Gobster et al., 2020; Foo et al., 2015). Following the literature on Attention Restoration Theory, green environments lead to a reduction in stress and attention restoration, only when they reflect compatibility with one's purposes and intentions and appear groomed to afford safe activities (Kaplan, 1995; Hadavi, 2017).

As additional limitations, the study used the 2020 HCS single-year dataset. An examination of data from multi-years would be of interest to compare results over time. Additionally, our study focused solely on greenness data during the summer months. Thus, the relationship between greenness and psychological well-being may vary across different seasons, and our findings do not capture the potential seasonal dynamics. Lastly, it would be valuable for future studies to explore alternative modeling approaches, such as examining the combined effects of vacancy and greenness on psychological well-being. This would provide insights into whether the relationship between greenness and psychological well-being is contingent upon the presence of an interaction effect, shedding light on potential nuanced dynamics that may exist. The findings encourage city planners and managers to consider the adaptive re-use of existing "greenness" in urban areas by improving physical and social attributes of these natural areas.

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Wonjin Jeong: Conceptualization, Methodology, Formal analysis, Visualization, Writing - Original Draft, Writing - Review & Editing. **Hyojung Kang**: Methodology, Validation, Writing - Review & Editing. **Seunguk Shin**: Conceptualization, Writing - Review & Editing. **Ajanta Patel**: Project administration. **Nikhil Prachand**: Data Curation, Project administration. **Meha Singh**: Data Curation, Project administration. **William Stewart**: Conceptualization, Resources, Supervision, Writing - Review & Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ali, M., Moses, A., Nakua, E.K., Punguyire, D., Cheabu, B.S.N., Avevor, P.M., Basit, K.A., 2022. Spatial epidemiology of bacterial meningitis in the Upper West Region of Ghana: analysis of disease surveillance data 2018–2020. Clin. Infect. Pract. 16 (July) https://doi.org/10.1016/j.clinpr.2022.100160.

Annerstedt van den Bosch, M., Mudu, P., Uscila, V., Barrdahl, M., Kulinkina, A., Staatsen, B., Swart, W., Kruize, H., Zurlyte, I., Egorov, A.I., 2016. Development of an urban green space indicator and the public health rationale. Scand. J. Public Health 44 (2), 159–167. https://doi.org/10.1177/1403494815615444.

Bedimo-Rung, A.L., Mowen, A.J., Cohen, D.A., 2005. The significance of parks to physical activity and public health. Am. J. Prev. Med. 28 (2S2), 159–168. https://doi.org/10.1016/j.ampre.2004.10.024.

Berland, A., Locke, D.H., Herrmann, D.L., Schwarz, K., 2020. Beauty or blight? Abundant vegetation in the presence of disinvestment across residential parcels and neighborhoods in Toledo. Oh. Front. Ecol. Evol. 8, 334. https://doi.org/10.3389/FEVO.2020.566759/BIBTEX.

Birch, J., Rishbeth, C., Payne, S.R., 2020. Nature doesn't judge you – how urban nature supports young people's mental health and wellbeing in a diverse UK city. Health Place 62, 102296. https://doi.org/10.1016/j.healthplace.2020.102296.

Boone, C.G., Buckley, G.L., Grove, J.M., Sister, C., 2009. Parks and people: an environmental justice inquiry in Baltimore, Maryland. Ann. Assoc. Am. Geogr. 99 (4), 767–787. https://doi.org/10.1080/00045600903102949.

Butler, E., 2016. Second chances for the second city's vacant properties: an analysis of chicago's policy approaches to vacancy, abandonment, & blight. Chic. -Kent. Law Rev. 91 (1), 233–266.
Callanan, J., Signal, T., McAdie, T., 2021. What is my child telling me? Reducing stress, increasing competence and improving psychological well-being in parents of children with a developmental disability. Res. Dev. Disabil. 114, 103984 https://doi.org/10.1016/j.ridd.2021.103984.
Chicago Department of Public Health. (2020). *Healthy Chicago 2025*. https://www.chicago.gov/content/dam/city/depts/cdph/statistics_and_reports/HC2025_917_FINAL.pdf.
Cronon, W., 1992. Nature's metropolis: Chicago and the Great West. W. W. Norton & Company.
Didan, K., 2015. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006 [Data set]. NASA EOSDIS Land Process. DAAC. https://doi.org/10.5067/MODIS/MOD13Q1.006.
Erickson, B., Johnson, C.W., Kivel, D.B., 2009. Rocky mountain national park: History and culture as factors in African-American park visitation. J. Leis. Res. 41 (4), 529–545. https://doi.org/10.1080/00222216.2009.11950189.
Fernandez, M., Harris, B., Rose, J., 2021. Greensplaining environmental justice: a narrative of race, ethnicity, and justice in urban greenspace development. J. Race, Ethn. City 2 (2), 210–231. https://doi.org/10.1080/26884674.2021.1921634.
Fernandez, M., Witt, P.A., 2013. Attracting Hispanics to an African American recreation center. J. Leis. Res. 45 (4), 423–444. https://doi.org/10.18666/jlr-2013.
Floyd, M.F., 1998. Getting beyond marginality and ethnicity: the challenge for race and ethnic studies in leisure research. J. Leis. Res. 30 (1), 3–22. https://doi.org/10.1080/00222216.1998.11949816.
Foo, K., Martin, D., Polsky, C., Wool, C., Ziemer, M., 2015. Social well-being and environmental governance in urban neighbourhoods in Boston, MA. Geogr. J. 181 (2), 138–146. https://doi.org/10.1111/geoj.12108.
Furukawa, T.A., Kawakami, N., Saitoh, M., Ono, Y., Nakane, Y., Nakamura, Y., Tachimori, H., Iwata, N., Uda, H., Nakane, H., Watanabe, M., Naganuma, Y., Hata, Y., Kobayashi, M., Miyake, Y., Takeshima, T., Kikkawa, T., 2008. The performance of the Japanese version of the K6 and K10 in the World Mental Health Survey Japan. Int. J. Methods Psychiatr. Res. 17 (3), 152–158. https://doi.org/10.1002/MPR.257.
Gee, G.C., Payne-Sturges, D.C., 2004. Environmental health disparities: a framework integrating psychosocial and environmental concepts. Environ. Health Perspect. 112 (17), 1645–1653. https://doi.org/10.1289/ehp.7074.
Getis, A., Aldstadt, J., 2010. Constructing the spatial weights matrix using a local statistic. Adv. Spat. Sci. 61 (2), 147–163. https://doi.org/10.1007/978-3-642-01976-0_11.
Gobster, P.H., 2001. Visions of nature: conflict and compatibility in urban park restoration. Landsc. Urban Plan. 56 (1–2), 35–51. https://doi.org/10.1016/S0169-2046(01)00164-5.
Gobster, P.H., Rigolon, A., Hadavi, S., Stewart, W.P., 2020. The condition-care scale: a practical approach to monitoring progress in vacant lot stewardship programs. Landsc. Urban Plan. 203 (June), 103885 https://doi.org/10.1016/j.landurbplan.2020.103885.
Groshong, L., Stanis, Wilhelm, Kaczynski, A.T., Kaczynski, A.T., Hipp, J.A., 2020. Attitudes about perceived park safety among residents in low-income and high minority Kansas City, Missouri, neighborhoods. Environment and Behavior 52 (6), 639–665. https://doi.org/10.1177/0013916518814291.
Gubbels, J.S., Kremers, S.P.J., Droomers, M., Hoefnagels, C., Stronks, K., Hosman, C., de Vries, S., 2016. The impact of greenery on physical activity and mental health of adolescent and adult residents of deprived neighborhoods: a longitudinal study. Health Place 40, 153–160. https://doi.org/10.1016/j.healthplace.2016.06.002.
Ha, J., Kim, H.J., With, K.A., 2022. Urban green space alone is not enough: a landscape analysis linking the spatial distribution of urban green space to mental health in the city of Chicago. Landsc. Urban Plan. 218, 104309 https://doi.org/10.1016/j.landurbplan.2021.104309.
Hadavi, S., 2017. Direct and indirecteffects of the physical aspects of the environment on mental well-being. Environ. Behav. 49 (10), 1071–1104. https://doi.org/10.1177/0013916516679876.
Hadavi, S., Rigolon, A., Gobster, P.H., Stewart, W.P., 2021. Resident-led vacant lot greening and crime: do ownership and visual condition-care matter? Landsc. Urban Plan. 211 (October 2020), 104096 https://doi.org/10.1016/j.landurbplan.2021.104096.
Hagan, J., McCarthy, B., Herda, D., 2022. Chicago's reckoning: Racism, politics, and the deep history of policing in an American city. Oxford University Press. https://doi.org/10.1093/oso/9780197627860.001.0001.
Henderson, H., Child, S., Moore, S., Moore, J.B., Kaczynski, A.T., 2016. The influence of neighborhood aesthetics, safety, and social cohesion on perceived stress in disadvantaged communities. Am. J. Community Psychol. 58 (1–2), 80–88. https://doi.org/10.1002/AJCP.12081.
Hughey, S.M., Walsemann, K.M., Child, S., Powers, A., Reed, J.A., Kaczynski, A.T., 2016. Using an environmental justice approach to examine the relationships between park availability and quality indicators, neighborhood disadvantage, and racial/ethnic composition. Landsc. Urban Plan. 148, 159–169. https://doi.org/10.1016/j.landurbplan.2015.12.016.
Iyer, H.S., Valeri, L., James, P., Chen, J.T., Hart, J.E., Laden, F., Holmes, M.D., Rebbeck, T.R., 2020. The contribution of residential greenness to mortality among men with prostate cancer: a registry-based cohort study of Black and White men. Environ. Epidemiol. 4 (2), e087 https://doi.org/10.1097/EE9.0000000000000087.
Jennings, V., Bamkole, O., 2019. The relationship between social cohesion and urban green space: an avenue for health promotion. Int. J. Environ. Res. Public Health 16 (3). https://doi.org/10.3390/ijerph16030452.
Jeong, W., Stewart, W.P., Gobster, P.H., van Riper, C.J., 2021. Green leisure: resistance and revitalization of urban neighborhoods. Leis. Sci. 1–21. https://doi.org/10.1080/01490400.2021.1889422.
Jin, H.Y., Kwon, Y., Yoo, S., Yim, D.H., Han, S., 2021. Can urban greening using abandoned places promote citizens' wellbeing? Case in Daegu City, South Korea. Urban For. Urban Green. 57 (November 2020), 126956 https://doi.org/10.1016/j.ufug.2020.126956.
Jo, J., Shin, S., Son, Y., An, B., 2022. Seniors' participation in gardening improves nature relatedness, psychological well-being, and pro-environmental behavioral intentions. J. People, Plants, Environ. 25 (3), 297–309. https://doi.org/10.11628/ksppe.2022.25.3.297.
Johnson, A.J., Glover, T.D., 2013. Understanding urban public space in a leisure context. Leis. Sci. 35 (2), 190–197. https://doi.org/10.1080/01490400.2013.761922.
Johnson, C.Y., Bowker, J.M., Cordell, H.K., Johnson, C., Bowker, J., Cordell, H., 2001. Outdoor recreation constraints: an examination of race, gender, and rural dwelling. J. Rural Soc. Sci. 17 (1), 111–133.
Kaplan, R., & Kaplan, S. (1989). The experience of nature: a psychological perspective. In *The experience of nature: a psychological perspective*. Cambridge University Press.
Kaplan, S., 1995. The restorative benefits of nature: toward an integrative framework. J. Environ. Psychol. 15 (3), 169–182.
Kephart, L., 2022. How racial residential segregation structures access and exposure to greenness and green space: a review. Environ. Justice 15 (4), 204–213. https://doi.org/10.1089/env.2021.0039.
Kessler, R.C., Andrews, G., Colpe, L.J., Hiripi, E., Mroczek, D.K., Normand, S.-L.T., Walters, E.E., Zaslavsky, A.M., 2002. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychol. Med. 32 (6), 959–976. https://doi.org/10.1017/S0033291702006074.
Kowarik, I., 2018. Urban wilderness: supply, demand, and access. Urban For. Urban Green. 29, 336–347. https://doi.org/10.1016/j.ufug.2017.05.017.
Labib, S.M., Lindley, S., Huck, J.J., 2020. Spatial dimensions of the influence of urban green-blue spaces on human health: a systematic review. Environ. Res. 180, 108869 https://doi.org/10.1016/j.envres.2019.108869.
Leslie, E., Sugiyama, T., Ierodiaconou, D., Kremer, P., 2010. Perceived and objectively measured greenness of neighbourhoods: Are they measuring the same thing? Landsc. Urban Plan. 95 (1–2), 28–33. https://doi.org/10.1016/J.LANDURBPLAN.2009.11.002.
Lioy, P.J., 1990. Assessing total human exposure to contaminants: A multidisciplinary approach. Environ. Sci. Technol. 24 (7), 938–945. https://pubs.acs.org/sharingguidelines.
López-Contreras, N., Puig-Barrachina, V., Vives, A., Olave-Müller, P., Gotsens, M., 2021. Effects of an urban regeneration program on related social determinants of health in Chile: a pre-post intervention study. Health Place 68, 102511. https://doi.org/10.1016/j.healthplace.2021.102511.
Lovejoy, K., Handy, S., Mokhtarian, P., 2010. Neighborhood satisfaction in suburban versus traditional environments: an evaluation of contributing characteristics in eight California neighborhoods. Landsc. Urban Plan. 97, 37–48. https://doi.org/10.1016/j.landurbplan.2010.04.010.
McCammack, B., 2017. Landscapes of hope: Nature and the Great Migration in Chicago. Harvard University Press.
Mikels-Carrasco, J., 2010. Nature in our own backyards: urban ecology and children. Child., Youth Environ. 20 (2), 190–199.
Moore, N.Y., 2019. The south side: A portrait of Chicago and American segregation. Picador Paper.
Natalie P. Voorhees Center. (2014). *The socioeconomic change of Chicago's community areas (1970–2010)* (Issue October).
Nath, T.K., Zhe Han, S.S., Lechner, A.M., 2018. Urban green space and well-being in Kuala Lumpur, Malaysia. Urban For. Urban Green. 36, 34–41. https://doi.org/10.1016/j.ufug.2018.09.013.
Nesbitt, L., Meitner, M.J., Sheppard, S.R.J., Girling, C., 2018. The dimensions of urban green equity: a framework for analysis. Urban For. Urban Green. 34, 240–248. https://doi.org/10.1016/j.ufug.2018.07.009.
Orians, G.H., Heerwagen, J.H., 1992. Evolved responses to landscapes. In: Barkow, J.H., Tobby, J., Cosmides, L. (Eds.), The adapted mind: Evolutionary psychology and the generation of culture. Oxford University Press, pp. 555–579.
Orsi, J.M., Margellos-Anast, H., Whitman, S., 2010. Black–White health disparities in the United States and Chicago: a 15-year progress analysis. Am. J. Public Health 100 (2), 349–356. https://doi.org/10.2105/AJPH.2009.165407.
Peters, K., Elands, B., Buijs, A., 2010. Social interactions in urban parks: stimulating social cohesion? Urban For. Urban Green. 9 (2), 93–100. https://doi.org/10.1016/j.ufug.2009.11.003.
Rajan, S.I., Cherian, A.P., 2021. COVID-19: urban vulnerability and the need for transformations. Environ. Urban. ASIA 12 (2), 310–322. https://doi.org/10.1177/09754253211040195.
Rhew, I.C., Vander Stoep, A., Kearney, A., Smith, N.L., Dunbar, M.D., 2011. Validation of the normalized difference vegetation index as a measure of neighborhood greenness. Ann. Epidemiol. 21 (12), 946–952. https://doi.org/10.1016/j.annepidem.2011.09.001.
Rigolon, A., 2016. A complex landscape of inequity in access to urban parks: a literature review. Landsc. Urban Plan. 153, 160–169. https://doi.org/10.1016/j.landurbplan.2016.05.017.
Rigolon, A., Browning, M., Jennings, V., 2018. Inequities in the quality of urban park systems: an environmental justice investigation of cities in the United States. Landsc. Urban Plan. 178 (January), 156–169. https://doi.org/10.1016/j.landurbplan.2018.05.026.
Rigolon, A., Browning, M., McAnirlin, O., Yoon, H., 2021. Green space and health equity: a systematic review on the potential of green space to reduce health disparities. Int.

J. Environ. Res. Public Health 18 (5), 2563. https://doi.org/10.3390/IJERPH18052563.
Rigolon, A., Németh, J., 2021. What shapes uneven access to urban amenities? Thick injustice and the legacy of racial discrimination in Denver's parks. J. Plan. Educ. Res. 41 (3), 312–325. https://doi.org/10.1177/0739456×18789251.
Rohe, W.M., 2009. From local to global: one hundred years of neighborhood planning. J. Am. Plan. Assoc. 75 (2), 209–230. https://doi.org/10.1080/01944360902751077.
Rook, K.S., 1984. The negative side of social interaction: impact on psychological well-being. J. Personal. Soc. Psychol. 46 (5), 1097–1108. https://doi.org/10.1037/0022-3514.46.5.1097.
RTI International. (2020). *2020 Healthy Chicago Survey (HCS): Methodology report*. https://www.chicago.gov/content/dam/city/depts/cdph/statistics_and_reports/2020_HCS_Methodology_Report.pdf.
Rugel, E.J., Henderson, S.B., Carpiano, R.M., Brauer, M., 2017. Beyond the Normalized Difference Vegetation Index (NDVI): Developing a Natural Space Index for population-level health research. Environ. Res. 159 (September), 474–483. https://doi.org/10.1016/j.envres.2017.08.033.
Ruijsbroek, A., Mohnen, S.M., Droomers, M., Kruize, H., Gidlow, C., Gražulevičiene, R., Andrusaityte, S., Maas, J., Nieuwenhuijsen, M.J., Triguero-Mas, M., Masterson, D., Ellis, N., van Kempen, E., Hardyns, W., Stronks, K., Groenewegen, P.P., 2017. Neighbourhood green space, social environment and mental health: an examination in four European cities. Int. J. Public Health 62 (6), 657–667. https://doi.org/10.1007/s00038-017-0963-8.
Shanahan, D.F., Lin, B.B., Bush, R., Gaston, K.J., Dean, J.H., Barber, E., Fuller, R.A., 2015. Toward improved public health outcomes from urban nature. Am. J. Public Health 105 (3), 470–477. https://doi.org/10.2105/AJPH.2014.302324.
Sikorska, D., Łaszkiewicz, E., Krauze, K., Sikorski, P., 2020. The role of informal green spaces in reducing inequalities in urban green space availability to children and seniors. Environ. Sci. Policy 108 (September 2019), 144–154. https://doi.org/10.1016/j.envsci.2020.03.007.
Soga, M., Gaston, K.J., Yamaura, Y., 2017. Gardening is beneficial for health: A meta-analysis. Prev. Med. Rep. 5, 92–99. https://doi.org/10.1016/j.pmedr.2016.11.007.
Sommet, N., Morselli, D., 2017. Keep calm and learn multilevel logistic modeling: a simplified three-step procedure using Stata, R, Mplus, and SPSS. Int. Rev. Soc. Psychol. 30 (1), 203–218. https://doi.org/10.5334/irsp.90.
Sreetheran, M., van den Bosch, C.C.K., 2014. A socio-ecological exploration of fear of crime in urban green spaces - A systematic review. Urban For. Urban Green. 13 (1), 1–18. https://doi.org/10.1016/J.UFUG.2013.11.006.
Stewart, W.P., Evans, N.M., 2021. Place-making for regional conservation negotiating narratives of stability and change. In: Raymond, C.M., Manzo, L.C., Williams, D.R., Di Masso, A., von Wirth, T. (Eds.), Changing senses of place: Navigating global challenges. Cambridge University Press, pp. 65–76.
Stewart, W.P., Williams, D.R., Kruger, L.E., 2013. Conclusion: From describing to prescribing—transitioning to place-based conservation. In *Place-Based Conservation: Perspectives from the Social Sciences*. Springer,, pp. 235–248. https://doi.org/10.1007/978-94-007-5802-5_18.
Stodolska, M., Shinew, K.J., Acevedo, J.C., Izenstark, D., 2011. Perceptions of urban parks as havens and contested terrains by Mexican-Americans in Chicago neighborhoods. Leis. Sci. 33 (2), 103–126. https://doi.org/10.1080/01490400.2011.550220.
Suglia, S.F., Shelton, R.C., Hsiao, A., Wang, Y.C., Rundle, A., Link, B.G., 2016. Why the neighborhood social environment is critical in obesity prevention. J. Urban Health 93 (1), 206–212. https://doi.org/10.1007/s11524-015-0017-6.
Tooke, T.R., Klinkenber, B., Coops, N.C., 2010. A geographical approach to identifying vegetation-related environmental equity in Canadian cities. Environ. Plan. B: Plan. Des. 37 (6), 1040–1056. https://doi.org/10.1068/b36044.
Trust for Public Land. (2021). *Park Score*. https://www.tpl.org/city/chicago-illinois.
U.S. Census Bureau. (2020). *QuickFacts: Chicago city, Illinois*. https://www.census.gov/quickfacts/fact/table/chicagocityillinois/PST045221.
Ulrich, R.S., 1981. Natural versus urban scenes: some psychophysiological effects. Environ. Behav. 13 (5), 523–556.
Ulrich, R.S., 1983. Aesthetic and affective response to natural environment. In: Altman, I., Wohlwill, J.F. (Eds.), Behavior and the natural environment. Springer US, pp. 85–125. https://doi.org/10.1007/978-1-4613-3539-9_4.
Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., Zelson, M., 1991. Stress recovery during exposure to natural and urban environments. J. Environ. Psychol. 11 (3), 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7.
Van Cauwenberg, J., Van Holle, V., De Bourdeaudhuij, I., Van Dyck, D., Deforche, B., 2016. Neighborhood walkability and health outcomes among older adults: The mediating role of physical activity. Health Place 37, 16–25. https://doi.org/10.1016/j.healthplace.2015.11.003.
van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., Maas, J., 2015. Health benefits of green spaces in the living environment: a systematic review of epidemiological studies. Urban For. Urban Green. 14 (4), 806–816. https://doi.org/10.1016/j.ufug.2015.07.008.
Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Clow, A., Miller, D., 2012. More green space is linked to less stress in deprived communities: evidence from salivary cortisol patterns. Landsc. Urban Plan. 105 (3), 221–229. https://doi.org/10.1016/j.landurbplan.2011.12.015.
Western Australian Planning Commission. (2015). *Liveable neighbourhoods*. https://www.dplh.wa.gov.au/getmedia/afb82ec4–31a5–4a14–8af4-c840b3c2b81e/ FUT-LiveableNeighbourhoods_2015.
White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H., 2013. Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. Psychol. Sci. 24 (6), 920–928. https://doi.org/10.1177/0956797612464659.
White, M.P., Pahl, S., Wheeler, B.W., Depledge, M.H., Fleming, L.E., 2017. Natural environments and subjective wellbeing: different types of exposure are associated with different aspects of wellbeing. Health Place 45, 77–84. https://doi.org/10.1016/j.healthplace.2017.03.008.
Wilson, J.Q., & Kelling, G.L. (1982, March). Broken windows. The Atlantic. https://www.theatlantic.com/magazine/archive/1982/03/broken-windows/304465/.
Wolch, J.R., Byrne, J., Newell, J.P., 2014. Urban green space, public health, and environmental justice: The challenge of making cities "just green enough. Landsc. Urban Plan. 125, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017.
Xu, W., Sun, H., Zhu, B., Bai, W., Yu, X., Duan, R., Kou, C., Li, W., 2019. Analysis of factors affecting the high subjective well-being of Chinese residents based on the 2014 China family panel study. Int. J. Environ. Res. Public Health 16 (14), 2566. https://doi.org/10.3390/ijerph16142566.