

The Role of Greenness of School Grounds in Student Violence in the Chicago Public Schools

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Abstract

Given that greener neighborhoods have reduced reports of physical and verbal conflict, greenness on school campuses may be instrumental for addressing young people's behavioral issues and creating safe school environments. Utilizing data about students' violent behaviors in the Chicago Public Schools, this study examines the potential impacts of greenery within a 100 m radius from Chicago primary and secondary schools on the frequency of offenses. This study finds that greater school greenness, measured using the Normalized Difference Vegetation Index, results in an increase in both non-weaponed and weaponed attacks and threats at K-12 schools.

Keywords: student violence, Chicago, greenness, school grounds

Introduction

A large volume of literature has provided evidence of the substantial benefits of green spaces on physical and mental health (Astell-Burt, Feng, & Kolt, 2013; Gascon et al., 2015; James, Banay, Hart, & Laden, 2015). Cross-sectional studies have documented that neighborhood greenness encourages physical activities, such as walking and recreational activities, which may in turn reduce the prevalence of health problems including obesity and overweight (Bell, Wilson, & Liu, 2008; Dzhambov, Markevych, Tilov, & Dimitrova, 2018; Richardson, Pearce, Mitchell, & Kingham, 2013). The advantages of nature appear to be more effective in disadvantaged communities (Ward Thompson et al., 2012). Because green spaces also reduce the risk of anxiety and stress in children (Wells, 2000; Wells & Evans, 2016), some scholars have argued that frequent exposure to greenery can enrich cognitive development in children and lower the rate of chronic absenteeism in schools (Berman, Jonides, & Kaplan, 2008; MacNaughton, Eitland, Kloog, Schwartz, & Allen, 2017). A growing number of studies have been conducted that support the positive effect of greenness at school sites on academic outcomes (Hodson & Sander, 2017; Matsuoka, 2010; Wu et al., 2014).

In addition to considerable studies examining the relationship between green spaces, psycho-physiological benefits and academic outcomes (Cohen-Cline, Turkheimer, & Duncan, 2015; Coutts, Chapin, Horner, & Taylor, 2013; Nutsford, Pearson, & Kingham, 2013), the focus of recent research on green spaces has expanded from the health problems and physical activities of individuals to community-level impacts of green space on disadvantages associated with crime and violence. Findings have indicated that the restorative effects of nature and its assistance with stress recovery can serve as intervention strategies for coping with crime and fear of crime (Bogar & Beyer, 2016; Kuo & Sullivan, 2001b; Shepley, Sachs, Sadatsafavi, Fournier, & Peditto, 2019). As greener neighborhoods report reduced physical and verbal conflict (Raney, Hendry, & Yee, 2019; Younan et al., 2016), greenness on school campuses may be instrumental for creating safer school environments as well as addressing children's behavioral issues (Flouri, Midouhas, & Joshi, 2014; Garvin, Cannuscio, & Branias, 2013). However, little attention has been directed to understanding violent behaviors among students in conjunction with greenness of school grounds. Although abundant research on student misconduct has traced trends in school disciplinary methods and investigated their effects, the majority of the literature has focused on the adverse consequences of school punitive sanctions, such as academic failure, dropouts, and eventual incarcerations (Balfanz, Byrnes, & Fox, 2014; Gregory, Skiba, & Noguera, 2010; Mowen, 2017; Rumberger & Losen, 2017). The extant research on school disciplinary practices has understudied the role of green school grounds on behavior; therefore, the potential for green spaces to help shape student conduct is yet unknown. This study explores the possibility that greenness on school grounds can mediate students' violent behaviors.

Green Spaces as a Buffer against or Catalyst for Violence

Research in this field rests on the assumption that criminal and delinquent behaviors are shaped by the interaction between individual problems and contextual factors surrounding them. Previous studies have pointed out that mental

fatigue relieved by nature and social support enhanced with frequent access to greenery can improve aggressive and offensive behaviors (Kaplan, 1995; Kuo & Sullivan, 2001a; Maas, van Dillen, Verheij, & Groenewegen, 2009). A growing interest in the restorative effects of nature has allowed scholars to examine the promotive role that neighborhood greenness may play in violence and crime prevention. Specifically, research that emphasizes greenness has provided a new perspective that physical environments, in addition to traditional community attributes such as race and poverty, can reinforce criminal motivations and opportunities (Anselin, Cohen, Cook, Gorr, & Tita, 2000; Smith, Frazee, & Davison, 2000).

Empirical evidence has demonstrated that increased exposure to nature in urban neighborhoods, largely brought about by planting more trees and developing parks, can mitigate violent crime in those neighborhoods (Burley, 2018; Kondo, Han, Donovan, & MacDonald, 2017). Contrary to the general fear that greening vacant spaces will attract illegal activity, public lots widely covered with tree canopies have been associated with a reduced probability of criminal activity, including assault, burglary, and vandalism (Donovan & Prestemon, 2010). As communities with higher tree and grass density have reported fewer crime incidents (Branas et al., 2011; Kuo & Sullivan, 2001b; Wolfe & Mennis, 2012), the expansion of vegetation cover in low-income communities has been expected to lower the incidence of violence and crime (Burley, 2018). Areas enhanced with greenery have shown a decline in gun-related crime, and residents have also reported greater perceived safety (Garvin et al., 2013). These studies have pointed to the “broken windows” theory, which argues that well-maintained communities are less likely to be targeted by crime, and the attention restoration theory, which addresses the effect of natural environments on recovering attention capabilities, as the primary mechanisms behind the relationship between increased greenery and decreased violent crime rates (Bogar & Beyer, 2016; Ceccato, Canabarro, & Vazquez, 2020; Gilstad-Hayden et al., 2015; Shepley et al., 2019).

Some studies, however, have generated mixed conclusions on the relation between green space and violence in different measurements and settings (Bogar & Beyer, 2016; Spader, Schuetz, & Cortes, 2016). Just as greenness in a neighborhood does not necessarily reduce residents’ cognitive fatigue or stress (Weeland, Laceulle, Nederhof, Overbeek, & Reijneveld, 2019), recent studies have demonstrated that neighborhood greenery can generate rather than moderate violence and crime (Groff & McCord, 2011). For example, community gardens in city cores failed to reduce property crime rates, including rates of burglary and theft (Gorham, Waliczek, Snelgrove, & Zajicek, 2009). Similarly, a study utilizing 12-year crime datasets has revealed a null association between the number of trees planted in a given city and the city's crime rate (Locke, Han, Kondo, Murphy-Dunning, & Cox, 2017). While greening interventions, such as constructing wooden fences and improving vegetation, can help residents to feel safer, there exists no evidence of a resulting decline in the overall crime rates or crime severity (Garvin et al., 2013; Gorham et al., 2009; Kondo, Fluehr, McKeon, & Branas, 2018; Snelgrove, Michael, Waliczek, & Zajicek, 2004).

Unequal Access to Green Spaces

Since accumulating findings indicate the physical and mental health benefits of green infrastructure (Coppel & Wüstemann, 2017; van den Berg, Maas, Verheij, & Groenewegen, 2010), urban planning has been deeply involved in improving residents' proximity to quality public parks, playgrounds, and gardens. However, recent studies that display the controversial impact of greenness on violence, crime, and safety have undermined the policy rationale of various land use planning efforts to enhance urban green spaces (Bogar & Beyer, 2016; Maruthaveeran & van den Bosch, 2014). This contradiction between empirical findings and policy practices requires special attention because the geographic distribution of green spaces has not been equitably granted to urban residents (Nesbitt & Meitner, 2016; Poudyal, Hodges, & Merrett, 2009). A systemic review of urban landscapes has delineated that areas with larger proportions of White residents and higher income levels have greater access to nature through community gardens, public parks, and tree-lined streets (Nesbitt, Meitner, Sheppard, & Girling, 2018; Schwarz et al., 2015; Wolch, Byrne, & Newell, 2014). Moreover, efforts to increase accessibility to greenness, such as by renovating and building parks in previously disinvested inner-city neighborhoods, have been associated with increased gentrification (Rigolon & Németh, 2020). Thus, house buyers who acknowledge the common merits of green space project a preference for closeness to greenery onto property values (Nesbitt, Hotte, Barron, Cowan, & Sheppard, 2017; Panduro & Veie, 2013; Troy & Grove, 2008).

Apart from access to greenness, types and sizes of urban green spaces also vary according to non-spatial attributes such as race and ethnicity, education attainment level, and poverty status. Many predominately Black communities in the U.S. have greater availability than White communities of public parks within approximately five minutes by foot, whereas high greenness quality, which is measured by tree density and park size, is more common in areas with a larger proportion of affluent and White residents (Boone, Buckley, Grove, & Sister, 2009; Poudyal et al., 2009; Sister, Wolch, & Wilson, 2010; Wendel, Downs, & Mihelcic, 2011). This locality-specific variation suggests that uneven geographies by demographic and socioeconomic factors are not always aligned with the presence or absence of greenery (Kabisch & Haase, 2014; Xu, Haase, Pribadi, & Pauleit, 2018). Given that distinct definitions and dissimilar measurements of vegetation have differently represented the magnitude of neighborhood greenness in a given space (Rhew, Vander Stoep, Kearney, Smith, & Dunbar, 2011; Tilt, Unfried, & Roca, 2007; Villeneuve et al., 2018), spatial unevenness of green spaces proposes that there is a non-linear link between green spaces and geographic clusters of violent behaviors and criminal incidents. With this in mind, the complex relationship between nature and violence calls for careful examination that incorporates both the existing disparities in socioeconomic attributes and spatial differentiation in greenery between and within communities.

Students' Behavior at Green School Sites

Although there has been no visible change in levels of school violence and crime for the last two decades (Wang, Chen, Zhang, & Oudekerk, 2020), a series of mass shootings throughout the United States and the seemingly unbreakable school-to-

prison pipeline have raised public concern and awareness regarding student misconduct and school disciplinary practices from longitudinal and multifaceted standpoints (Gerlinger et al., in press; Kirk & Sampson, 2012; Welsh et al., 2008). Nearly half of American public schools had school police officers or security guards in the 2017-18 school year, and about 70 percent of U.S. public schools experienced at least one violent incident (Diliberti, Jackson, Correa, & Padgett, 2019). Work to date has sought explanations for school violence and juvenile crime from non-environmental factors such as race, ethnicity, gender, and income level (Sartain, Allensworth, & Porter, 2015; Skiba et al., 2011), as well as family structure and background (Ferguson, San Miguel, & Hartley, 2009; Sampson, 1997; Zimmerman & Messner, 2013). Recently, substantial attention has been allocated to the influence of peer interaction and exposure to community crime in predicting and preventing young people's misbehavior (Burdick-Will, 2017; Dubow, Huesmann, Boxer, & Smith, 2016; Fontaine, Brendgen, Vitaro, & Tremblay, 2016; McAra & McVie, 2016; Resnick, Ireland, & Borowsky, 2004). Although some studies have supported the role of social networks and cultural capital in youth violence and student misbehavior, their predictive power and results of the corresponding interventions are still inconsistent (Ferguson et al., 2009; Houry-Kassabri, Benbenishty, Astor, & Zeira, 2004). This calls for further investigation into the school grounds at which children and youth spend a considerable amount of time.

With the positive impact of greenery on test scores (Browning, Kuo, Sachdeva, Lee, & Westphal, 2018; Hodson & Sander, 2017; Wu et al., 2014), increased contact with greenness, specifically on schoolyards, has been expected to influence even non-academic outcomes and behavioral issues (Matsuoka, 2010). Closeness to greenery has improved hyperactivity and inattention and lessened the level of life stress in both urban and rural children (Arbogast, Kane, Kirwan, & Hertel, 2009; Kelz Evans, & Röderer, 2015; McCormick, 2017; Taylor, Kuo, & Sullivan, 2001; Wells & Evans, 2016). Young people surrounded by greener indoor and outdoor spaces are less likely to be involved in aggressive activities and to experience emotional problems (Flouri et al., 2014; Markevych et al., 2014; van den Bogerd et al., 2020; Younan et al., 2016). Urban children and adolescents with nearby green space tend to be involved in fewer fights and physical attacks, irrespective of the amount of time to which they were exposed to trees and grass (Wells & Evans, 2016; Younan et al., 2016). Such preventive effects of green space have been well-reported in youth from socioeconomically marginalized families (Bates, Bohnert & Gerstein, 2018). This large body of literature that describes the advantages of nature for school-age children has provided substantial support for initiatives to create green schoolyards for the purpose of minimizing behavioral issues in students (Astor, Meyer, & Behre, 1999; Johnson, 2009). Current studies on greenness of school grounds have focused on identifying causal pathways for academic, psychological, and emotional effects (Chawla, Keena, Pevec, & Stanley, 2014; Kelz, Evans, & Röderer, 2013; Lorenc et al., 2012; Mårtensson et al., 2014; Williams & Dixon, 2013); this study aims to examine the connection between violent behaviors among students and the greenness of school grounds. By expanding empirical knowledge about the role of green school spaces, this study can offer in-depth information on the frequency and severity of violence and disruptive behavior among school-age children and youth.

Data and Methods

School Violence in Chicago

To explore whether or not violent behavior among young people at school sites can be mediated by an environmental factor, specifically greenness at a given school site, this research focuses on student disciplinary data in the City of Chicago School District #299, also known as the Chicago Public Schools (CPS). Chicago, the largest city in Illinois (in the midwestern U.S.), has a population of 2.7 million, which includes 35 percent non-English speakers and 50 percent non-White residents. Chicago, which has long struggled with unchanging statistics of crime and criminal law enforcement, has shown a drastic increase in crimes involving firearms and weapons between 2013 and 2016 (Hamilton & Foote, 2018; Towers & White, 2017). Furthermore, recent efforts for urban revitalization in Chicago have worsened uneven geographies by displacing underserved populations (Lipman, 2017; Smith, 2014). Although there has been a recent decline of the school-aged population in Chicago that has led to mass school closures (Lee & Lubienski, 2017), as the third-largest urban school district in the U.S. (following New York City and Los Angeles), Chicago served approximately 350,000 students at around 600 schools in the 2018-19 school year. Thirty-three percent of the total students in CPS are White, and about 40 percent of them are from low-income households, as indicated by their parents being eligible for the Food Stamp Program and the Supplemental Nutrition Assistance Program (SNAP).

Utilizing the 2015-16 Civil Rights Data Collection provided by the U.S. Department of Education, this study focuses on four indicators of school violence that frequently result in in-school and out-of-school suspensions and expulsions: 1) the number of fights or incidents of physical attack without a weapon, 2) the number of physical attacks or fights with a weapon, 3) the number of threats of physical attack without a weapon, and 4) the number of threats of physical attacks with a weapon. As presented in Table 1, data from 429 primary schools serving kindergarten through 8th-grade students and 142 secondary schools serving 9th grade or above indicates there is a greater mean frequency of fights and threats without a weapon per school than incidents with weapons during the selected academic year. Across the U.S., 96,360 school sites reported 787,200 total incidents of physical attack or fight without a weapon, and 197,900 threats of physical attack without a weapon (Office for Civil Rights, 2019). However, the pattern of school offenses in Chicago has shown that threats—unweaponed or weaponed—occur more frequently on school grounds than do fights or physical attacks.

Table 1. Description of the selected violence indicators at school sites in Chicago

	Mean	SD	Min	Max
Fights or physical attack without a weapon	1.705	10.395	0	148
Fights or physical attack with a weapon	0.140	2.501	0	60
Threats of physical attack without a weapon	8.853	23.168	0	483
Threats of physical attack with a weapon	0.199	2.523	0	60

Greenness of School Grounds

This study defines school grounds as the space within a 100 m (equivalent to .06 mile) radius from the school boundaries, which is distinct from the common approach of measuring school locations as a census tract or five-digit postal code area. By including school surroundings as well as school grounds, this research can utilize neighborhood context as a proxy for school environments and thus offer a more comprehensive understanding of the findings (Burdick-Will, 2017; Lubienski & Lee, 2017). We obtained the geographic information about the school sites from the CPS school campus boundary map and Google Earth. Previous studies have assessed greenness in urban areas with a variety of measurements, including the number of trees planted, the percentage of tree canopy, and the park area (Li, Chiang, Sang, & Sullivan, 2019; Locke et al., 2017; Sister et al., 2010). Since green spaces on urban school properties can consist of a variety of green plants such as trees, shrubs, and grass (Schulman & Peters, 2007), this study measures the greenness of an individual school ground using the Normalized Difference Vegetation Index (NDVI), which is extracted from National Aeronautics and Space Administration (NASA) data. Widely used in relevant studies (e.g., MacNaughton et al., 2017; Rhew et al., 2011; Wu et al., 2014), NDVI is a spectrum-based vegetation indicator, which indicates 0 for no greenness and 1 for rich and healthy greenness (Crippen, 1990).

Figures 1 and 2 exhibit spatial variations of NDVI across the CPS school grounds linked with the selected four violence-related misbehavior indicators at school sites for the 2015-16 school year. Figures 1a and b presents the spatial distributions of non-weaponed school violence, specifically in physical attacks or fights and threats of physical attack. Both maps in Figure 1 indicate that schools with higher frequencies of attack or threat of attack without a weapon, represented by larger white circles, are surrounded by light grey-gradated areas reflecting a moderate level of vegetation from .3 through .6. The large white circles do not appear in areas with a low or high density of vegetation; rather, community schools in areas with modest greenery report more incidents of unweaponed attacks and fights.

Figure 1a. Spatial distribution of greenness and incidence of student violence without a weapon on school grounds

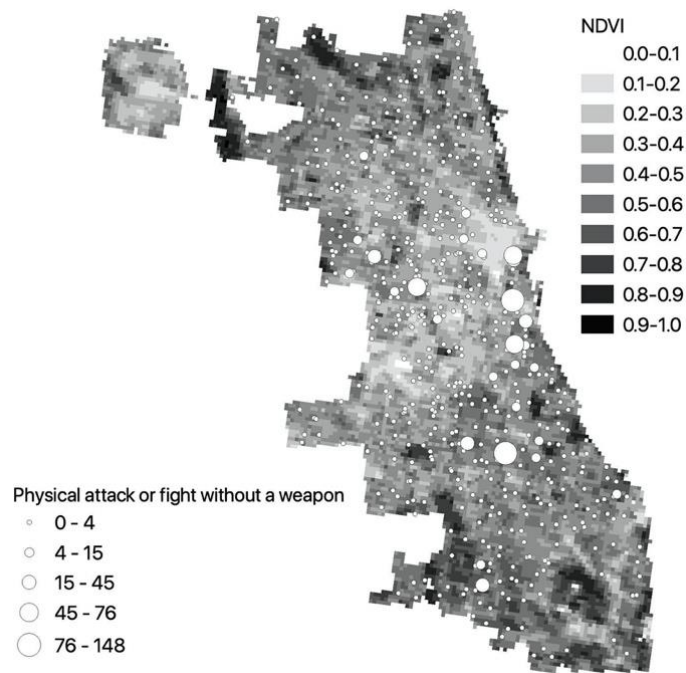
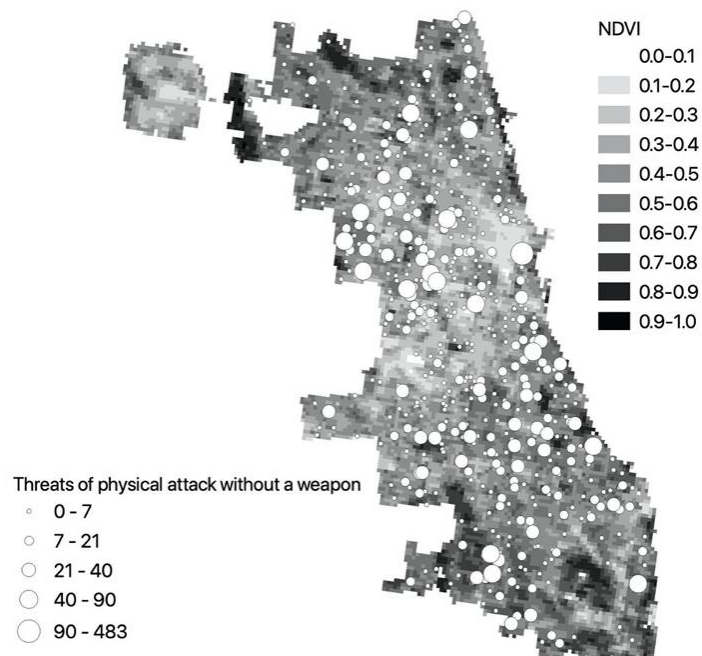


Figure 1b. Spatial distribution of greenness and incidence of threatened student violence without a weapon on school grounds



Figures 2a and b illustrate the geographical patterns of weapon-based threats and attacks or fights in CPS. The two distributions in Figure 2 suggest that many CPS schools show a high frequency of school threats and attacks without a weapon. Though the prevalence of school threats exhibits an overall irregular pattern, schools with a high prevalence of weapon-based attacks and fights are located in regions with moderate vegetation indices. Recurring threats with weapons at school campuses occur more in the comparatively greener regions of northern and southern Chicago than in the central areas of Chicago, which are colored in light grey. Only several schools adjacent to the Loop, a central business area in downtown Chicago with sparse greenery with the NDVI values below .3, record higher frequencies of physical attacks and fights.

Figure 2a. Spatial distribution of greenness and incidence of student violence with a weapon on school grounds

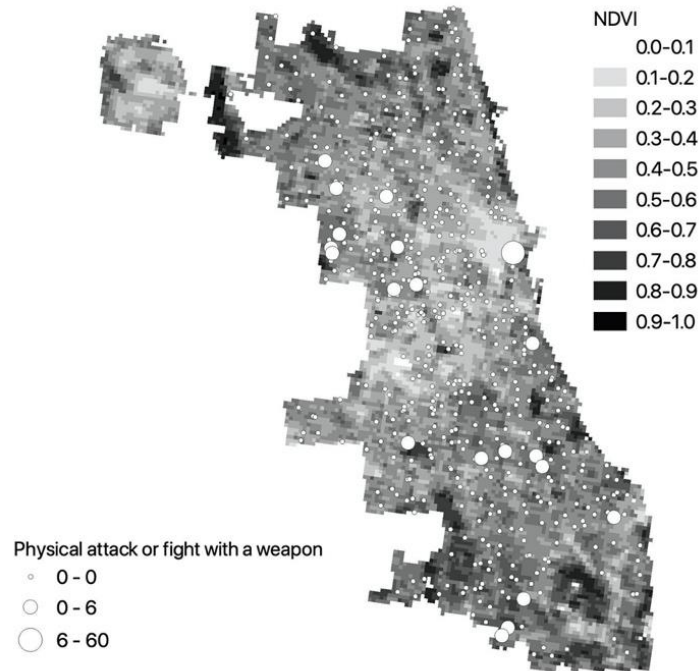
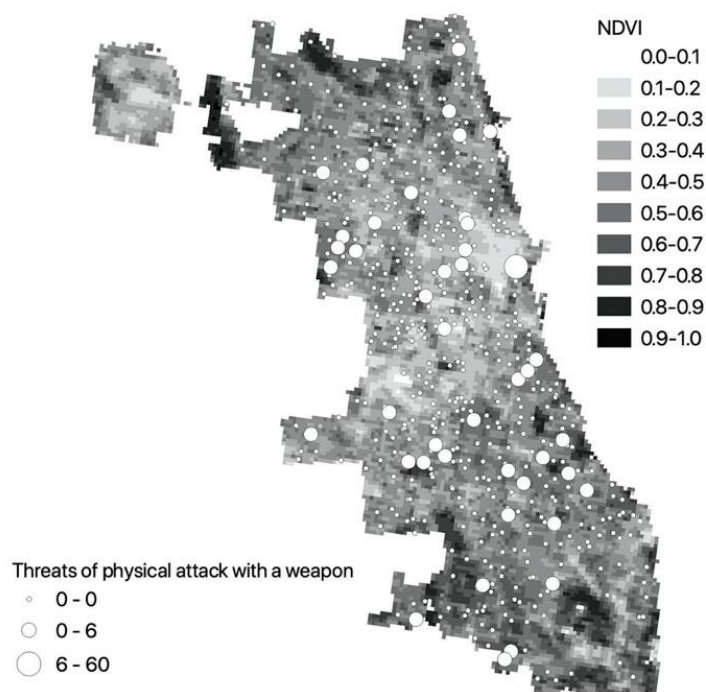


Figure 2b. Spatial distribution of greenness and incidence of threatened student violence with a weapon on school grounds



Statistical Analysis

We conducted further research on the maps in Figures 1 and 2 to discover whether and how closeness to greenness at school grounds is associated with varying levels of student attacks and threats, given the divergence in NDVI across the city. By integrating the NDVI datasets with multiple spatial layers, this study employs two regression models that are widely used for count data, the Poisson regression and negative binomial regression models. As the 2015-16 Civil Rights Data Collection is built on the count of fights and offending incidents in schools, the application of a common regression, such as the ordinary least squares models, can present an inaccurate estimation of the NDVI value on violent behaviors among students (Boggess, 2013; Gardner, Mulvey, & Shaw, 1995; Huang & Cornell, 2012). Though the Poisson regression has been widely adopted in criminology research using count data, distributions of the selected four indicators for student violence can be over-dispersed with greater variances from a Poisson formulation than their means (Berk & MacDonald, 2008; Cameron & Trivedi, 1990; Dean, 1992). On the basis of this result, we tested the effect of greenness at school sites on non-weaponed physical attacks or fights and threats of physical attack with the negative binomial regression model, and we used the Poisson regression model for weapon-based incidents.

As the purpose of this study is to explore the potential role of green space within a 100 m radius from school boundaries in decreasing the frequency of offenses, this study takes into account basic demographic and socioeconomic covariates of

individual schools: the student body composition, the school level (primary vs. secondary), the proportion of students eligible for free or reduced lunch programs, the percentage of the population by race and ethnicity, the population by the level of educational attainment, the unemployment rate, the vacancy rate, the median income, and the percentage of owner-occupied housing units. These community features in a given census tract are extracted from the 2014-18 American Community Survey 5-year estimates from the U.S. Census Bureau.

This study also incorporates the number of indexed crime incidents reported in Chicago during the year of 2015 to represent the community context surrounding schools. The Chicago Police Department defines indexed crime as serious offenses including the following crime categories: homicide, sexual assault, robbery, aggravated assault and battery, burglary, larceny, motor vehicle theft, and arson.

Findings

As represented in darker grey in Figures 1 and 2, some schools in which unweaponed threats frequently occur are spatially clustered in communities with moderate or high vegetation index values. To provide accurate information about the role of greenness as a buffer against or catalyst for student violence-related misbehaviors beyond the current spatial illustrations, Figures 1 and 2 need to take into account neighborhood spillover effects. The following analysis demonstrates the extent to which student misconduct is associated with greenness in conjunction with community attributes such as median income and crime rate.

Student Violent Misconduct without a Weapon

Employing the negative binomial model due to the overdispersion of non-weaponed incidents of physical attack or fight and threat of attack, Table 2 presents the estimated effect of the greenery of school grounds and their neighborhoods on violent incidents at school sites. In the null models, which present only the relationship between school violence and school greenness by taking no account of the covariates of the common community characteristics listed above, one increase in greenness of school grounds is associated with a decrease of the expected log count of threats without a weapon by .011. The coefficient of greenness for non-weaponed physical attacks is not statistically significant.

On the grounds that voluminous literature has suggested the prominence of family, school, and community features in student misconduct, the two full models in Table 2 present the estimated effect of school ground greenness measured by NDVI on the incidents of student violence without a weapon when other common factors are held equal. The full model for physical attacks or fights without a weapon shows a statistically significant effect of greenery in school surroundings in comparison with its null model. Both negative binomial models indicate that one unit change in the magnitude of school greenness yields an increased log count for attacks and threats without a weapon, albeit at a weak significance level of .10. This suggests that schools with greener environments are more likely to report incidents of unweaponed student misconduct.

Overall, the log counts of fights or incidents of physical attack without a weapon are influenced by the neighborhood characteristics of higher minority enrollments, fewer adults without a college degree, and more owner-occupied housing units. Increased populations of color in school neighborhoods are associated with a declining frequency of non-weaponed fights and attacks. In the full model of the frequency of threats of physical attack without a weapon, the size of the student population and the proportion of the populations identified as non-White show a nonsignificant difference in the incidences. Rather, an increase in the number of students eligible for free or lunch reduced programs, one of the most widely used indicators for low socioeconomic status, raises the frequency of non-weaponed threats by 1.966. The logged median income level and the number of households with housing ownership, in the full negative binomial model for threats of attack without a weapon, suggest that economically stable school neighborhoods can heighten the number of school threats. The estimated impact of neighborhood crime rates increases only the log frequency of threats without a weapon. Also, secondary schools serving students in 9th grade or above report fewer unweaponed incidents than do primary schools.

Student Violent Misconduct with a Weapon

In comparison with the negative binomial models for non-weaponed incidents on school grounds, the two null Poisson models present the statistically significant effects of greenness on weapon-based attacks and threats. The null models demonstrate the positive impact of school greenness with decreased log counts of fights or attacks by .124 and threats by .089, given a significance level of .01, respectively.

Although all of the null negative binomial and Poisson regression models support greenness of school grounds as a positive influence on student behavior, the full models in Table 2 of the weaponed incidents demonstrate a consistent, negative impact of school greenery across the selected violent misconduct types. In the same manner as the findings of non-weaponed incidents, greater numbers of physical attacks or fights with a weapon and threats of physical attack without a weapon occur in greener school grounds. With every 1 percent increase in school greenery, the estimated log counts of incidents using weapons increase by .075 for attacks or fights and .040 for threats respectively. Furthermore, the changes in NDVI highlight that the association between greenness and weaponed attacks or fights is substantially greater than that with weapon-based threats when all other factors are held equal.

Similar to the patterns of unweaponed incidents on school grounds in Table 2, a higher proportion of students of color leads to more reports of weaponed incidents; however, a greater proportion of minority groups in the population presents a significantly negative connection with weapon-based threatening at school sites. Although eligibility for free or reduced lunch programs and the logged median income level have nonsignificant effects on the two student violence types assessed with the Poisson model, the proportion of owner-occupied housing units contributes to raising a probability that schools record more frequent school threats with a weapon. This suggests that common factors, including eligibility for school lunch

aids and geographically identifiable community attributes, do not fully account for the prevalence of student violent misconduct. The increases in non-White populations and vacancy rates in school neighborhoods yield a statistically significant decline in the log frequency of weaponed threats. As constant exposure of school-aged children and youth to crime-prone communities negatively affects a range of outcomes later in life (Burdick-Will, Stein, & Grigg, 2019; Santiago & Galster, 2014; Tisak, Wichorek, & Tisak, 2011), the indexed crime incidents partly result in the rise of physical attacks or fights and threats of attack with a weapon. Contrary to the estimated effect of school levels in the negative binomial models, transition from primary school to secondary school does not have an impact on the log counts of physical attacks or threats of attack with a weapon.

Table 2. Estimated effects of the contextual variables on student violence

	Negative binomial model for non-weaponed incidents				Poisson model for weapon-based incidents			
	Attack or fight		Threat		Attack or fight		Threat	
	Null	Full	Null	Full	Null	Full	Null	Full
Intercept	.678 (.714)	-23.740* (9.704)	2.668*** (.299)	-8.706** (4.281)	2.995*** (.415)	-30.686 (21.514)	2.084*** (.366)	-23.047** (11.068)
NDVI	-.003 (.015)	.025* (.015)	-.011* (.006)	.012* (.007)	-.124*** (.012)	.075** (.029)	-.089*** (.010)	.040** (.016)
School level (Secondary=1)		-1.518*** (.269)		-.888*** (.127)		-.403 (.465)		-.276 (.285)
African- American students (%)		8.316*** (1.891)		1.204 (.751)		20.269* (12.189)		7.348*** (2.581)
Hispanic-Latinx students (%)		6.820*** (1.954)		.678 (.772)		21.231* (12.007)		7.987*** (2.593)
Students eligible for lunch programs (%)		.994 (1.461)		1.966*** (.582)		10.100 (6.859)		-.479 (1.820)
African- American population (%)		-6.090*** (1.403)		-.036 (.614)		-3.029 (3.370)		-3.588** (1.642)
Hispanic-Latinx population (%)		-7.153*** (1.560)		-.103 (.664)		-2.532 (3.693)		-4.736*** (1.838)
Population with no college degree (%)		5.981*** (1.743)		.239 (.756)		.208 (3.857)		2.848 (2.137)
Logged median income		1.344* (.778)		.687** (.346)		-.470 (1.497)		1.025 (.876)
Unemployment rate		-1.114 (2.542)		-.282 (1.176)		-2.997 (4.443)		1.284 (2.709)
Vacancy rate		1.408 (2.089)		-.648 (.980)		2.579 (3.391)		-4.127* (2.240)
Owner- occupied housing units (%)		2.715** (1.249)		1.234** (.552)		.791 (2.490)		3.662** (1.456)
Indexed crime incidents		.002 (.004)		.006*** (.002)		.025*** (.004)		.018*** (.002)
Theta (θ)	.081	.166	.465	.651				
AIC	1253.9	1150.8	3540.5	3396.6	743.98	205.93	915.79	416.39

Discussion

While many researchers have considered the direct and explicit impact of greenness on violence and crime, comparatively little educational research attention has been dedicated toward exploring the significance of proximity to greenness in student behavior. This study utilizes the Poisson and negative binomial regression models to seek answers to whether a difference in access to green school campuses could moderate the prevalence of student violence at school sites. The basic models, which focus on the interplay between school offenses and greenness, provide support to the claim that vegetation is capable of moderating violent and criminal behaviors (e.g., Kondo et al., 2017; Wolfe & Mennis, 2012). However, the full models, holding an extensive array of contextual community features equal, unveil that the estimated effects of school greenery on violent misbehaviors among school-aged children and youth contrast with the result of the null models. Notably, access to greenery in school surroundings, defined as an area within a 100 m radius from the school boundaries, may increase the number of incidents of physical attack or threat and the number of threats of attack.

The adverse effect of greenery on both unweaponed and weaponed attacks and threats echoes the concern that greenery can attract misconduct (Garvin et al., 2013; Snelgrove et al., 2004). Although there is less debatable evidence for the close causal connection between green spaces and mental and physical health (Beyer et al., 2014; Gascon et al., 2015), much research on greenness has demonstrated inconsistent, weakly positive, and sometimes even negative relationships between green space and crime (Du & Law, 2016; Lorenc et al., 2012). Given that densely wooded areas and untouched grasslands have been found to keep residents from feeling safe (Kuo & Sullivan, 2001b), the findings of this study indicate that greenness at school grounds and their adjacent surroundings, measured in vegetation density, may be associated with increased frequencies of physical attacks and threats of attack at school sites.

It should, however, be noted that the NDVI dataset for vegetation represents only one aspect of greenness within a pixel. NDVI for greenery has offered a glimpse of the vegetation activity of a given land surface, especially in urban areas in which land use principally consists of buildings, parking lots, and streets (Chen, Weeks, & Kaiser, 2005). An increase in the NDVI value simply reflects increased potential access to greenery, irrespective of the actual use and purpose of the green spaces. This measurement provides scant information on what composes the vegetation of a certain area and how it is experienced in daily life (Nesbitt & Meitner, 2016; Villeneuve et al., 2018). For instance, fear of crime with regard to greenery is greater in untouched and unmonitored green areas, which have a high NDVI value, than in better maintained but less-green parks (Heinze et al., 2018; Maruthaveeran & van den Bosch, 2014). Well-structured and well-maintained green spaces, which can be distinguished from dense vegetation computed with the NDVI values, have also discouraged crime frequencies, thus supporting the broken windows theory (Burley, 2018; Shepley et al., 2019). This suggests that differentiated types and uses of greenness may serve as a more accurate estimate for the impact of school greenery on young people's behavior. Therefore, the findings of this study, which demonstrate the negative side of greenness of school grounds on students'

behaviors, call for further research on the relationship between student violent misbehavior and environmental factors by the type of natural areas.

Apart from the shortcomings of the NDVI data, the harmful influence of greenness on violent behaviors shown in this study revisits the argument about nonlinear causal relationships between green spaces and violence-related incidents. In the circumstance that children and youth have had inequitable access to green parks and playgrounds (Boone et al., 2009; Oh & Jeong, 2007; Sister et al., 2010; Talen & Anselin, 1998), the interplay between neighborhood disadvantages and varied experiences of greenness might enhance or neutralize the role of green school grounds on students' violent behaviors. A well-established body of literature has empirically supported that greenness in urban areas has become more available to populations with certain racial, income, age, and education level characteristics (Comber, Brunsdon, & Green, 2008; Stodolska, Shinew, Acevedo, & Izenstark, 2011; Wüstemann, Kalisch, & Kolbe, 2017). Aligned with prevailing spatial inequity (Barnett, 2018; Soja, 2010), access to trees and grass has varied by demographic and socioeconomic features as well as by geographic locations and yielded results differentiated by urban intensity and economic factors (Hodson & Sander, 2019; Jennings, Johnson Gaither, & Gragg, 2012; Lin, Meyers, & Barnett, 2015; Ttofi, Farrington, Piquero, & DeLisi, 2016). In light of environmental injustice coupled with demographic attributes and socioeconomic features, the spatial variation of greenness in urban areas such as Chicago justifies ongoing debates on the advantages and disadvantages of green school campuses (Sister et al., 2010; Talen, 1997). Under this uneven greenness, disparities between observed and perceived greenness by community pose a further challenge to accurately estimate the robust impact of green spaces on troublesome behaviors (Cohen et al., 2016; Foster et al., 2015; Francis, Martin, Wood, & Foster, 2017; Hipp, Gulwadi, Alves, Sequeira, 2016; Leslie, Sugiyama, Ierodiaconou, & Kremer, 2010). Taken together, improved greenery on school grounds may either increase or reduce the number of incidents of school offenses in combination with community characteristics (Kimpton, Corcoran, & Wickes, 2017).

Although this study raises questions about the connection between vegetation on school grounds and young people's behaviors, greenness alone is not enough to account for student misbehavior and school violence (Wolch et al., 2014). High-stakes testing in the neoliberal era and gun deaths in American schools have increasingly brought correctional changes to school environments into focus, which include growing school security and surveillance systems, an expansion of zero-tolerance policies, and frequent police referrals (McAndrews, 2001; Na & Gottfredson, 2013; Skiba & Rausch, 2006). This over-dependence on punitive actions at school campuses may lead to criminalizing nonviolent actions and the disorderly conduct of students at school sites (Office for Civil Rights, 2014; Robers, Zhang, Morgan, & Musu-Gillette, 2015; Rocque & Paternoster, 2011). Nevertheless, given that school environments have played a part in the cumulative effect of predictive factors on violent behaviors (Andershed, Gibson, & Andershed, 2016; Kim, Gilman, Hill, & Hawkins, 2016), a different level of greenery outside the homes of school-aged children and youth can moderate physical attacks and threats at school (Taylor, Kuo, & Sullivan, 2002). In light of the necessity of

preventive and restorative efforts in school disciplinary practices and the increasing global attempts toward a better understanding of green schoolyards (Kelz et al., 2015; Mejía-Castillo, López-Suárez, Estrada Rodríguez, & Lagunes-Córdoba, 2016), further investigation that examines the potential of green infrastructure as a moderator is needed to elaborate the discourse on the role of nature in the prevention of student misbehavior.

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