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Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Green infrastructure and violence: Do new street trees mitigate violent crime?

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ARTICLE INFO

Keywords:

New trees
Green gentrification
Neighborhood violence
Mental health
Equitable green infrastructure practices

ABSTRACT

Exposure to violence has been deemed as a public health epidemic due to its negative impact on mental health outcomes, especially for residents of neighborhoods where violent crime is prevalent. Access to nature has the potential to mitigate diminished mental health outcomes, such as aggression. However, current literature specifying effective and equitable green infrastructure practices is lacking. The purpose of this study was to measure the extent to which Portland's green infrastructure initiative reduced neighborhood violence by increasing the availability of new trees to residents of underserved communities as a modality for green infrastructure intervention. Lagged multilevel modeling was used to determine whether an increase in new street trees resulted in reduced violent crime counts in the years following the planting of the trees. Results indicated that there was a strong negative correlation between the number of trees planted and violent crimes in the years following the planting of trees, net of neighborhood covariates. This effect was especially pronounced in neighborhoods with lower median household income. These findings suggest that the inclusion of new street trees in underserved neighborhoods may be one solution to the endemic of violence in such neighborhoods.

1. Introduction

Exposure to neighborhood violence may have a profound negative impact on residents of high crime neighborhoods, especially on mental health outcomes (Stockdale et al., 2007). Residents of high crime neighborhoods experience an increase in stress levels when neighborhoods are perceived as dangerous or threatening (Ross et al., 2000). Victims of crime and individuals who witness crime are at an increased risk of post-traumatic stress disorder (Cooley-Quille et al., 2001; Fehon et al., 2001; Robinson and Keithley, 2000). The risk of deleterious mental health outcomes associated with neighborhood violence is increasingly prevalent among low income neighborhoods (Chaix et al., 2006). Adolescents are especially vulnerable to exposure to neighborhood violence. According to the Surgeon General, for adolescents residing in economically disadvantaged urban neighborhoods, exposure to community violence has been designated as a “public health epidemic” (U.S. Surgeon General's Office, 2001). Research suggests that between 76% and 98% of adolescents in such neighborhoods have witnessed community violence at least once in their lifetime (Campbell and Schwarz, 1996). According to a study conducted by Lambert and colleagues, adolescents who witnessed community violence were much more likely to engage in aggressive behavior than adolescents who didn't witness community violence (Lambert et al., 2012). This type of

behavior sets the scene for a self-perpetuating cycle of increased violent crime among adolescents and adults alike in underserved communities. In fact, research suggests that adolescent exposure to violence is associated with subsequent adult violent offending and victimization (Menard, 2002; Franzese et al., 2016).

Kaplan and Kaplan (1989) forwarded the Attention Restoration Theory, which posits that urban dwellers experience an excess of hard fascination (or overstimulation), which leads to cognitive fatigue. This fatigue can lead to anxiety and depression. In addition, Kaplan and Kaplan (1989) presented evidence that cognitive fatigue can lead to “outbursts” of anger, which can increase rates of violence. However, nature may serve as a salubrious antidote against the negative psychological consequences of urban living. Indeed, research suggests that vegetation is positively associated with social cohesion and a productive and healthy social ecosystem (Kuo, 2003). Implementation of green infrastructure, such as trees, has also been associated with reduced crime rates (Kuo and Sullivan, 2001). Furthermore, some studies suggest that the combination of recreational outdoor walking and social cohesion can significantly improve mental health (Sugiyama et al., 2008).

Portland, Oregon's Grey to Green, green infrastructure initiative was unique in that it increased the availability of green infrastructure to underserved neighborhoods by offering a free tree to each resident.

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<https://doi.org/10.1016/j.healthplace.2018.08.015>

Received 27 April 2018; Received in revised form 3 August 2018; Accepted 22 August 2018

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Building on these findings and the framework of the Attention Restoration Theory, this study sought to measure the extent to which Portland's green infrastructure initiative was successful in reducing violent neighborhood crime. In this study, green infrastructure was defined as the planting of new trees in neighborhoods. Studies that incorporate crime data in analyses measuring vegetation and crime are scant. [Kuo and Sullivan \(2001\)](#) was the first to incorporate police crime data in measuring the association between vegetation and crime. However, that study was limited to pre-existing vegetation and crime reports for apartment buildings over a period of two years. Relatedly, the maintenance of the vegetation was not a factor in the analysis, as the vegetation included may have dated back to the 1940's ([Kuo and Sullivan, 2001](#)). The current work is the first study to examine the association between the introduction of new trees in neighborhoods and all violent crime counts over the span of five years. Further, this is the first study to incorporate multilevel modeling to measure the extent to which trees impacted violent crime counts both within neighborhoods over time and between them while controlling for time varying covariates associated with crime and gentrification. In addition, this is the first study to test the confounding effects that changing median household income may have had on violent crime counts. This is a necessary addition to the current literature because neighborhood greening programs, which can positively impact neighborhoods, have the potential to negatively affect certain residents within those neighborhoods ([Curran and Hamilton, 2012](#)). Understanding the types of programs that benefit the greatest number of people is vital in creating healthier communities.

2. Review of literature

2.1. Adverse health effects of exposure to violence

Exposure to community violence creates notable physical and mental health concerns that are deserving of attention ([U.S. Surgeon General's Office, 2001](#)). In addition to the wide array of mental health issues associated with exposure to violence, which include depression, anxiety, and PTSD, physical symptoms have also been reported ([Bailey et al., 2005](#)). Research has noted the negative long-term effects that community violence may have on the physiological structure of the brain. [LeDoux \(1993\)](#) found that living in a hypervigilant state due to the constant threat of community violence results in a prolonged hyperactivation of the neurological structure of the brain that manages threat and threat detection. Somatic difficulties have also been associated with such a state ([Reynolds et al., 2001](#)). Additionally, detrimental physical health outcomes, such as higher than average gestational weight gain, have also been linked to neighborhood violence ([Galín et al., 2017](#)). Outcomes such as these have the potential to negatively impact both the physical and mental health outcomes at an intergenerational level.

2.2. Mitigating effects of green infrastructure

Green Infrastructure has the potential to mitigate the destructive effects of exposure to violence in underserved neighborhoods. A study in Chicago measured the relationship between the number of trees surrounding a neighborhood and rates of property and violent crime. The study found that more trees were associated with lower property and violent crime rates ([Kuo and Sullivan, 2001](#)). There are several theories that explain such association. [Jacobs \(1961\)](#) posited the theory that increased surveillance would deter crime. The crime prevention through environmental design theory postulated that potential offenders would avoid newly greened areas if those areas were frequented by patrons ([Kondo et al., 2018](#)). Indeed, studies have suggested that areas with more trees attracted more patrons, which resulted in a reduction of crime ([Coley et al., 1997](#)). Another study showed that this held true even when observers weren't actually present ([Jeffery, 1971](#)). Additionally, green infrastructure and social cohesion are highly

correlated. A study conducted by Sampson and colleagues revealed that social cohesion was strongly and negatively associated with neighborhood violence ([Sampson et al., 1997](#)). One of the neighborhood factors that can increase the risk of neighborhood violence is low social cohesion ([Kondo et al., 2018](#)). Because residents of underserved neighborhoods are at a higher risk for witnessing community violence, policies incorporating green infrastructure interventions may be useful in fostering social cohesion and mitigating aggressive behaviors in those communities.

Nature also has the potential to improve cognition functioning and emotion. [Kaplan and Kaplan \(1989\)](#) suggested that urban dwellers experience an excess of hard fascination that leads to cognitive fatigue. This fatigue may be accompanied by an increase in aggression. However, nature may serve as a buffer against cognitive fatigue. [Mooney and Nicell \(1992\)](#) noted an increased level of violence among Alzheimer patients in facilities without gardens. Alternatively, in facilities where gardens were installed, violence either remained the same or decreased. This study was significant in highlighting the relationship between cognitive functioning and nature because aggression and violent behavior among Alzheimer patients is highly common due to the progressive deterioration of cognitive functioning. A study conducted by [Ulrich \(1979\)](#) helped to explain the relationship between nature and human emotion. After administering a psychologically taxing task, a group of 46 students were split into two groups; one group viewed slides of nature and the other group viewed slides of urban buildings devoid of litter or graffiti. After the students completed a survey, the results indicated that the students who viewed the nature scenes experienced an increase in positive emotions, (i.e. feelings of happiness). On the other hand, the students who viewed the urban scenes experienced the opposite: an increase in feelings of sadness. [Selhub and Logan \(2012\)](#) incorporated the use of electroencephalograph (EEG) measures in a study and observed that viewing scenes of nature was associated with higher alpha wave activity, which is indicative of increased positive emotions.

2.3. Examples of successful green infrastructure initiatives

Several green infrastructure initiatives have been successful in reducing crime and creating safer environments for underserved communities. The examples mentioned here are alike in their response to ruinous land use characteristics commonly found in economically disadvantaged communities, such as vacant lots. For example, The Youngstown Neighborhood Development Corporation's 'Lots of Green' program, a community reuse project that was initiated and maintained by local community groups, proved effective in providing a wide array of benefits to the community. One of the primary benefits observed was a significant reduction in violent crime rates. This study, which examined violent crime rates over twenty-five months, revealed significant reductions in violent crimes ([Kondo et al., 2016](#)). Another green infrastructure program that has proven effective in reducing crimes is Philadelphia's Green Stormwater Infrastructure Program (GSI). An evaluation of the initiative indicated that there were significant reductions in narcotics possessions and residential burglaries, which, in turn, increased neighborhood safety ([Kondo et al., 2015](#)).

2.4. Introduction to Portland's Grey to Green initiative

The purpose of Portland's Grey to Green Initiative was to expand the city's green infrastructure. This includes implementation of green streets and ecoroofs, planting of trees in urban areas, removing invasive species and revegetating, and planting in natural areas. A primary aim of the program was to create sustainable storm-water management practices under the guidance of Portland's Watershed Management Plan. In underscoring the ecosystem benefits of trees in its annual report, Portland's Bureau of Environmental Services also recognized the physical and mental health benefits that trees have on a community

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