Green Space, Violence, and Crime: A Systematic Review

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Abstract

Purpose: To determine the state of evidence on relationships among urban green space, violence, and crime in the United States. **Methods and Results:** Major bibliographic databases were searched for studies meeting inclusion criteria. Additional studies were culled from study references and authors' personal collections. Comparison among studies was limited by variations in study design and measurement and results were mixed. However, more evidence supports the positive impact of green space on violence and crime, indicating great potential for green space to shape health-promoting environments. **Conclusion:** Numerous factors influence the relationships among green space, crime, and violence. Additional research and standardization among research studies are needed to better understand these relationships.

Keywords

community violence, violence exposure, criminology, green space, community health, systematic review

Introduction

The presence of green space is now widely viewed as a health-promoting characteristic of urban environments and has been linked to numerous benefits including recovery from mental fatigue (Berman, Jonides, & Kaplan, 2008; Berman et al., 2012; Faber & Kuo, 2009; Hartig, Evans, Jamer, Davis, & Garling, 2003; Hartig, Mang, & Evans, 1991; Kaplan, 1995; Taylor & Kuo, 2008) positive childhood development (Chatterjee, 2005; Louv, 2008), and neighborhood social cohesion (Cohen, Inagami, & Finch, 2008; Maas, van Dillen, Verheij, & Groenewegen, 2009). Research has also demonstrated that increased access to green space may be linked to reductions in crime, violence, and aggression, (Branas et al., 2011; Garvin et al., 2013; Kuo & Sullivan, 2001a, 2001b) and that rates of violence can be influenced by systematic alterations of neighborhood environments—in particular, by the greening of vacant, urban land parcels (Branas et al., 2011; Garvin et al., 2013). However, the relationship between green space, crime, and violence remains largely unexplored, hindering momentum of greening interventions that could improve population health and reduce health disparities.

Foundations of Crime, Violence, and the Built Environment

Despite the relatively recent nature of studies exploring violence, crime, and urban green space, there is a long-standing history of social theories and law enforcement strategies that can help inform relationships among all three. Social disorganization is one of the oldest theories examining social interactions and health outcomes. Developed by Chicago School researchers Shaw and McKay in 1942, the theory posits that in communities that do not share common values, residents lose both social control and social capital, leading to a higher prevalence of neighborhood crime and violence (Kawachi, Kennedy, & Wilkinson, 1999; Veysey & Messner, 1999). Since its inception, social disorganization theory has been the target of criticism and skepticism, with questions raised about the utility and interpretation of the theory, assumed stability of land use and crime, and issues of measuring social processes (Veysey & Messner, 1999). However, several studies also demonstrate supportive evidence of social disorganization, and it remains a widely cited theory in studies examining relationships between neighborhood characteristics and health (Lowenkamp, Cullen, & Pratt, 2003; Sampson & Groves, 1989; Veysey & Messner, 1999).

Building on the idea of social cohesion as a positive attribute for community health, many studies pinpoint Jane Jacobs' classic 1961 book, "The Death and Life of GreatAmerican Cities," as the first exploration of ways in which urban planning and elements of the built environment can shape community living and health conditions. Most significantly, Jacobs advocated for

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open gathering spaces to facilitate community bonding and increase the number of "eyes on the street" or natural surveillance of areas within a community. The concept evolved, with sociologists transforming the concept into what is better known as "collective efficacy," and retains close ties to social cohesion and social capital, all of which are important tactics in decreasing crime and violence (Wen, Hawkley, & Cacioppo, 2006).

The 1970s and 1980s saw the formation of crime prevention theories and strategies among law enforcement that involved altering features of the environment, including "Broken Windows" theory and Crime Prevention Through Environmental Design (CPTED; Jeffery, 1971; Wilson & Kelling, 1982). Broken Windows theory proposes that signs of physical disorder (i.e. graffiti, vacant lots, and trash) send messages that the space is uncared for and that the surrounding community is not invested, hence criminal activity can proceed without consequences (Wilson & Kelling, 1982). Similarly, CPTED combines elements of psychology and architecture, focusing mainly on housing design and features of residential lots, with the intention of creating "defensible spaces" and minimizing opportunities for criminal behavior and activities (Jeffery, 1971; Newman, 1972).

Although studies on the community impact of crime and violence are limited, it is clear there is a rich history of social theory and law enforcement tactics to build upon (Dannenberg et al., 2003). Today, researchers are increasingly calling for the employment of social ecological models of violence and crime that provide a multilevel picture of violence and crime, which, when separated can help to further understandings of complex relationships (Dahlberg & Krug, 2002). Moving forward, the application and testing of social ecological models may help to further inform causal mechanisms behind violence and crime.

Urban Green Space, Violence, and Crime

The aforementioned social theories and law enforcement strategies supply evidence of a long recognized understanding of connections between the built environment and population health. In addition, the history highlights complex ways that environmental features and communities interact, leading to positive and negative community health outcomes. Today's growing green space research literature also illustrates both positive and negative relationships among urban green space, violence, and crime. Of particular concern are studies demonstrating that urban green space can become occupied gang territory, space to sell and distribute drugs, and grounds for illegal dumping (Branas et al., 2011; Brownlow, 2006; Stodolska, Shinewa, Acevedoa, & Izenstarka, 2011). In addition, a couple of studies suggest that green spaces can exacerbate discrimination and hostility between racially and ethnically homogenous neighborhoods as well as gangs vying for territory through the creation of "green walls" that physically divide neighborhoods (Gobster, 1998; Stodolska et al., 2011).

A more established body of research also highlights the importance of community *perceptions* of crime, violence, and urban green space. One of the most common fears arises when vegetation impedes visibility and appears to limit one's ability to easily escape (Jorgensen, Hitchmough, & Calvert, 2002; Kaplan & Kaplan, 1989; Nasar & Fisher, 1993; Scroeder, 1984). Similarly, studies describe resident fears that urban green space vegetation can hide criminals, which can lead to communities limiting their use of or altogether avoiding the space, thus missing out on numerous green space benefits (Jackson, Dannenberg, & Frumkin, 2013; Jorgensen, Hitchmough & Calvert, 2002; Parsons, 1995; Michael, Hull, & Zahm, 2001). The perception of green spaces as contributors of *increased* violence and crime can itself be detrimental to communities, as studies demonstrate associations between the fear of crime and violence and decreased physical activity, poorer mental health, and increased risk of cardiovascular and chronic disease (Browning, Cagney, & Iveniuk, 2012; Evenson et al., 2012; Guite, Clark, & Ackrill, 2006; Lorenc, 2012). Hence, future research exploring relationships among urban green space, violence, and crime must remain cognizant of the potential for resident *perceptions* of urban green spaces as places that harbor crime and violence.

Despite perceptions of urban green spaces as harbors of violence and crime, evidence from other studies refutes these perceptions. Recently, innovative and multidisciplinary research that directly explores relationships among urban green space, violence, and crime demonstrates exciting findings that position urban green space as a facilitator in *decreasing* crime and violence, often through the same mechanisms that researchers have used to explain other green space health benefits (Branas et al., 2011; Kuo & Sullivan, 2001a, 2001b). Given these divergent notions of relationships among urban green space, violence, and crime, and the potential for greening solutions to improve numerous public health problems, including crime and violence, a deeper understanding of existing evidence is needed. In particular, there is a need to systematically determine the direction of relationships between urban green space, violence, and crime, the quantitative significance of the relationships, and the causal mechanisms facilitating the relationships. Subsequently, a systematic review was conducted to examine the state of the evidence on empirical, quantitative relationships among urban green space, crime, and violence.

Methodology

A systematic review was carried out in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) systematic review guidelines (Liberati et al., 2009) in order to identify peer-reviewed papers that empirically examined the relationships between green space and either crime or violence. Primary research studies published in English and in the United States were eligible for inclusion. Only quantitative or mixed-methods studies were included in order to quantify associations between green space, crime, and violence and to differentiate from literature on the observational perception of crime, violence, and green spaces.

Because the primary relationship of interest was between green spaces and incidents of crime and violence, study

populations were not specified other than being residents of the United States. In addition, following an initial scoping of literature on urban green space and health, no specific type of green space was identified, as research studies on a more narrowed type of green space would produce too few studies to examine. Similarly, given the small number of studies explicitly examining the relationship between green spaces, violence, and crime in an initial literature search, this review was not restricted to certain types of crime or violence.

Search Strategy

Studies were initially identified by searching the electronic databases Medline, PsychInfo, Scopus and Ebscohost, which included Academic Search Premier, Greenfile, and Master-search. Authors originally intended to employ google scholar as they were interested in whether an interdisciplinary search engine would provide increased numbers of articles and more relevant articles than traditional databases limited by journal and discipline. However, based on numerous google scholar searches, it was concluded that the employment of google scholar as a comparative method is not currently feasible because of the inability to limit searches to journal articles and import articles in bulk to bibliographic files. In addition, different search algorithms make comparisons incompatible. Among remaining databases, studies were limited to peer-reviewed journals, English language, and a U.S. study location. The main search strategy is listed subsequently. Search terms were altered as necessary for different database formatting purposes:

(urban population* OR urban residents* OR cities* OR neighborhood* OR public housing*) AND (green space* OR trees* OR parks* OR landscape architecture* OR greening* OR *city planning* OR environmental design* OR ecosystem* OR environment* OR urban design*) AND (crime* OR crime statistics* OR violence) AND (outcome* OR program evaluation*).

Green was eliminated as a search term, as identified studies were largely irrelevant. Additional studies were selected through manual searches of references of the included studies and authors' personal collections.

Selection of Studies

There were five stages in selecting studies for inclusion in the systematic literature review, that is, (i) identification of studies from databases, bibliographies, and reviews; (ii) screening of titles; (iii) screening of abstracts; (iv) review of full paper; and (v) in-depth review of final selected papers to ensure fit. The study selection process is presented in Figure 1. In total, 3,155 studies were identified through the four databases searched (Stage 1). Of these, 3,032 studies were removed based on title (Stage 2). Among remaining studies, 104 were removed following abstract review (Stage 3). Following, 19 studies were reviewed in full (Stage 4). Finally, 9 were excluded, leaving a total of 10 studies in the final review (Stage 5).

Data Extraction and Analysis

Due to the substantial heterogeneity of methods and outcomes, two tables were created. Table 1 compares study characteristics with categories including study location, study design and analysis, type of green space, type of crime or violence, measurement of green space, measurement of crime or violence, and the unit of analysis. Table 2 was constructed to compare study findings by key predictors (green space) and outcomes (crime and violence). Green space predictor categories include the density of vegetation, green interventions, and trees. Violence and crime outcome categories include property crimes, nuisance crimes, intrafamily aggression and violence, violent crimes, and total crimes. To reiterate, there are numerous variations in selected study analysis techniques, outcomes, and causal explanations as well as a limited number of selected studies. Therefore, narrative synthesis is used to describe the 10 selected studies, as it would not be appropriate or feasible to conduct a meta-analysis (Higgins & Green, 2011). Effect sizes reported in the selected studies are provided as reported (correlation coefficients and regression coefficients). Final analyses included in the tables were adjusted for covariates by the original authors unless otherwise noted.

Results

Results, Study Characteristics

The 10 selected studies were conducted in the United States, beginning in 2001 and continuing through our April 2013 search (Table 2). Table 2 illustrates study variation and facilitates study comparison by study location, study design and analysis, predictor type of green, the type of crime or violence, green measurement, crime and violence measurement, unit of analysis, and theoretical grounding. Collectively, the studies represent several major regions in the United States. Five studies took place on the East Coast: three studies were conducted in Philadelphia, Pennsylvania, one in Baltimore, Maryland, one in Boston, Massachusetts; two studies took place in the South, both in Texas (Austin and Houston); two studies were conducted in the Midwest, both in Chicago, Illinois; and one was conducted on the West Coast in Portland, Oregon. Study designs also varied: seven studies were cross-sectional studies, one was a case study, one was a randomized control trial, and one was a longitudinal study. Study analyses included three studies that used ordinary least squares regressions, two that used Pearson's correlation, one that used a time series linear regression, one that tabulated calls made to the police, and one that used Poisson models. For the predictor type of green space, five studies incorporated trees (two trees and grass, two tree canopy, and one only trees), two used greened vacant lots, one used a linear park, one used community gardens, and one used only vegetation (grass, trees, shrubs, groundcover, and plants).

To measure green space, two studies compared vacant lots before and after greening, three used aerial photography
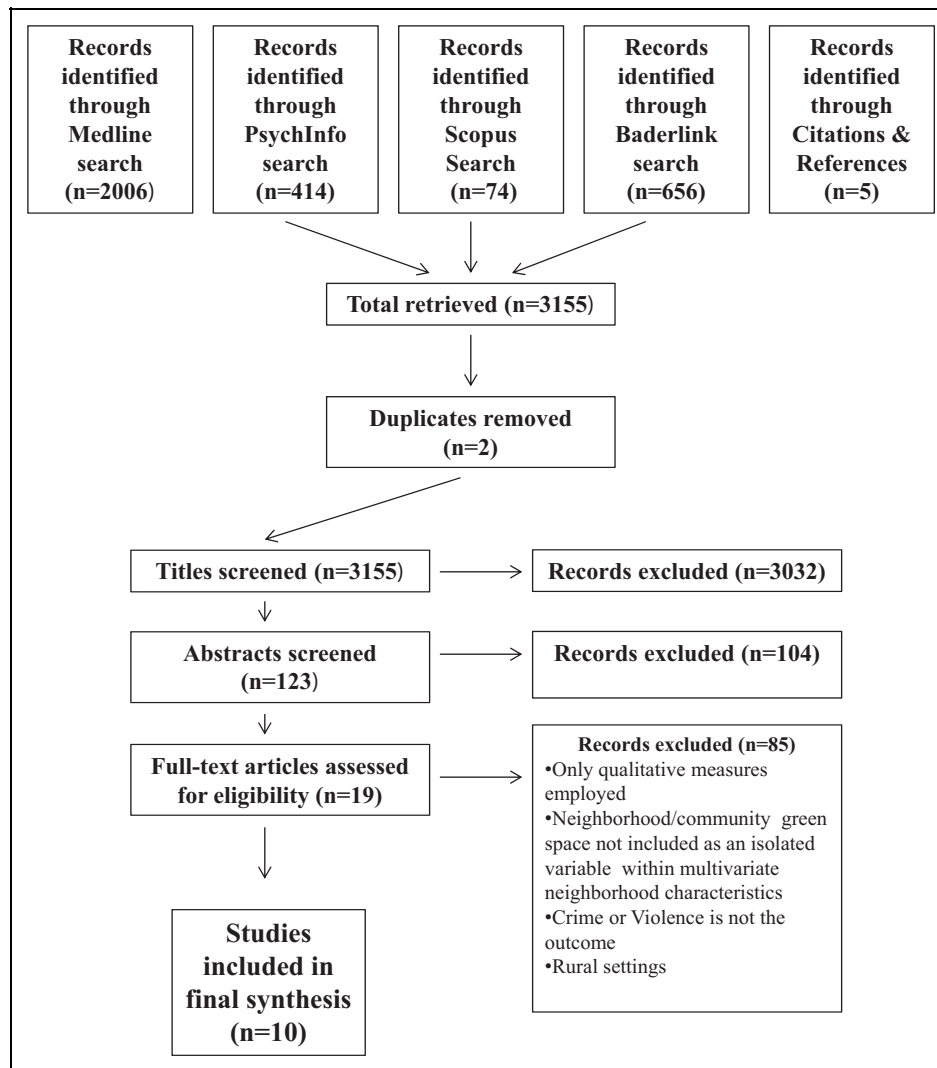
Figure 1. Search Strategy.

to measure tree canopies, two used proximity to green space (park and community gardens), two used ground-level photographs that were rated by student reviewers to determine "level" of green (0–4 rated scale, where 0 = *no green* and 4 = *very green*), and two used the normalized difference vegetation index to calculate the average density of green around a defined area.

Among all studies, several types of crime and violence outcomes were considered, which were combined into property crimes, violent crimes, aggression against partner and child, psychological and violent aggression, and total crimes. Similarly, studies used a variety of crime and violence measurements. One study used a violence severity score of 1–6, with one ranking as the most severe and six as the least severe. Another study employed the Conflict Tactics Scale, to measure intrafamily aggression and violence. Finally, two studies measured crime rate, two studies measured crime density, and four studies measured the number of crimes in a defined space.

There were also wide variations in the units of analysis across studies, reflecting differences in scale and differences in how "communities" were defined. Communities included apartment building complexes, neighborhoods, cities, and city and county boundaries. For the unit of analysis, two studies used census block data, two used public housing apartment buildings (with one scaling down to individual apartment units), one used block proximity to a park, one used four city sections, one used residential addresses, one used a half-mile radius around vacant lots before and after greening, and one used inner-city boundaries. Finally, for theoretical grounding and explanation, four studies cited attention restoration (though only one empirically explored this construct), three cited social theories including Jacobs' "eyes on the street" or theories of improved social control and social cohesion, one cited incivilities theory, one cited Jeffery's CPTED, and one cited Routine Activity theory. Routine Activity theory posits that crime occurs when a target is available, when there is an absence of people to intervene, and when the offender is motivated (Groff, 2007).

Table 1. Study Characteristics.

	Property Crimes	Nuisance Crimes	Intrafamily Violence and Aggression	Violent Crime	Total Crime
Density of healthy vegetation (NDVI, aerial photography)	Vegetation increase, total property crime *decrease* (KuoB). Vegetation increase, robberies *decrease* (Wolfe). Vegetation increase, burglaries *decrease* (Wolfe)		Vegetation increase aggression against family *decrease* (KuoA)	Vegetation increase total violent crime *decrease* (KuoB). Vegetation increase aggravated assault *decrease* (Wolfe)	Vegetation increase total crime *decrease* (KuoB). Vegetation increase total crime *decrease* (Snelgrove)
Greening intervention	Vandalism and criminal mischief *decrease* in ¼ city sections (Branas). Vandalism *increase* (Garvin). Burglary *increase* (Garvin). Theft *decrease* (Garvin). Robbery *increase* (Garvin)	Disorderly conduct *increase* (Branas). Disorderly conduct *decrease* (Garvin). Illegal dumping *increase* in ¼ city sections (Branas). Narcotics use and distribution *increase* (Garvin)		Gun violence *decrease* (Branas). Aggravated assault with and without a gun *decrease* (Garvin) Robbery with and without a gun *increase* (Garvin)	Total crime *decrease* (Garvin)
Trees	Large (size) trees *decrease* all property street crime (Donovan). Burglary: large (size) trees *decrease* residential lot, street crime (Donovan). Burglary: Increased number of trees on residential property lot *increase* (Donovan). Vandalism: large (size) trees *decrease* residential lot, street crime (Donovan)				Large (size) trees *decrease* lot, street crime (Donovan). Increased number of trees on residential property lot *increase* (Donovan). 11.8% *decrease* in total crime rate for 10% increase in tree canopy cover (Troy)

Note. NDVI = normalized difference vegetation index.

Results, Study Outcomes

Outcomes for type of crime and violence were categorized into property crimes, nuisance crimes, aggression (intimate partner violence), violent crimes, and total crime (see Tables 1 & 2 for additional information). Categories are grouped in Table 1 to improve comparison. Aggregated property crime variables include burglaries, illegal dumping, larceny, street robbery, residential robbery, car theft, vandalism, arson, and attempted burglary. Aggregated violent crime variables include assault, aggravated assault, aggravated assault with guns, robberies with guns, battery, murder, manslaughter, and attempted aggravated assault. Nuisance crimes include criminal mischief, disorderly conduct, narcotics sales and possession, and public drunkenness. Aggression includes intrafamily aggression and violence as measured by the Conflict Tactics Scale. Total crime includes the sum of all crime and violence variables considered by the authors, which authors categorized as "total crime."

Relationships tested across all types of green space, crime, and violence among selected studies demonstrated 19 instances of reductions in crime or violence related to green space. In contrast, relationships demonstrating increases in crime and violence related to green space were found in nine instances. Among property crimes, two studies found four instances of increases in property crimes (vandalism, two burglaries, and robbery) while five studies found eight instances of decreases in property crimes (two total property crimes, two burglaries, one robbery, one theft, and one vandalism). Among nuisance crimes, two studies found increases in three types of crime (disorderly conduct, illegal dumping, and narcotics use and distribution) and one study found a decrease in disorderly conduct. Within the study on intimate partner violence, a decrease in aggression against partners was found. Only one study found an increase in violent crime (robbery with and without a gun) when compared to four studies that found a decrease in violent

Table 2. Study Outcomes.

Paper	Study Location	Study Design and Analysis	Predictor: Type of Green	Outcome: Type of Crime/Violence	Green Measurement	Crime/Violence Measurement	Unit of Analysis	Theoretical Grounding
Branas et al. (2011)	Philadelphia, Pennsylvania, USA	Longitudinal cross-sectional time series linear regression	Vacant lots "greened" with trees and grass	Property crimes: (burglaries, criminal mischief, disorderly conduct, illegal dumping, narcotics sales or possession, and public drunkenness). Violent crimes: (aggravated assault, aggravated assaults + guns, robbery, and robberies + guns)	Randomized vacant lot controls compared with "greened" vacant lots in a 3:1 ratio	Crime density: point locations of crime for each lot, census tract, kernel density, and block group measures	4 City sections	Broken windows theory; Incivilities theory
Crewe (2001)	Boston, Massachusetts, USA	Case study: Police calls tabulated one per household per block per year	Linear park	Property crimes: (larceny, street robbery, and car theft) Bodily harm and disturbances: (minor disturbances, bodily harm, malicious mischief, assault, and battery)	Proximity to Boston Southwest Corridor Parkland	Number of police calls: Police calls tabulated one per household per block per year	Blocks adjacent to corridor, residential blocks, and commercial blocks within two 0.5-miles strips of corridor	Newman's CPTED
Donovan and Prestemon (2010)	Portland, Oregon, USA	Cross-sectional. Three Poisson models: sum of all crimes on property, sum of property crimes, sum of violent crimes Burglary, Vandalism Probit models	Trees	Property crimes: (burglary, larceny, motor vehicle theft, and vandalism). Violent crimes: (aggravated assault, robbery, and simple assault)	Aerial photography, tree crown area (size of trees on lot, street, and block + number of trees on lot, street, and block)	Number of crimes within 50-m, 100-m, and 200-m buffers around each house from 2002 to 2004	Residential addresses	Routine activity theory; Broken Windows; Attention Restoration theory
Garvin, Cannuscio, and Branas (2013)	Philadelphia, Pennsylvania, USA	Randomized control trial. Difference-in-difference analysis.	Vacant lots "greened" with trees and grass	Property crimes: (burglaries, criminal mischief, disorderly conduct, illegal dumping, narcotics sales or possession, and public drunkenness). Violent crimes: (aggravated assault, aggravated assaults + guns, robbery, and robbery + guns)	Two randomized vacant lot controls clusters compared with two "greened" vacant lot clusters	Number of crimes within a half mile buffer around vacant lots 3.5 months prior to and after greening	Half-mile radius around two vacant lots	Attention restoration theory; Social cohesion
Gorham, Waliczek, Snelgrove, and Zajicek (2009)	Houston, Texas, USA	Cross-sectional linear regression	Community gardens	Property crimes: (auto theft, burglary, and theft)	Proximity to 11 community gardens	Number of crimes within 1/8 miles buffer of community gardens when compared to crime within 1/8 mile buffer of 55 random control point areas	Census block data	N/A
Kuo and Sullivan (2001a)	Chicago, Illinois, USA	Cross-sectional ordinary least squares regression	Trees and grass	Aggression: aggression against partner, child. Psychological and violent aggression	Ground level photographs rated on a green scale of 0–4 (0 = no green, 4 = very green) by 22 student raters	Conflict tactics scale: psychological or violent aggression? If violent, mild, or severe violence?	Public housing: individual apartment units	Attention restoration theory

(continued)

Table 2. (continued)

Paper	Study Location	Study Design and Analysis	Predictor: Type of Green	Outcome: Type of Crime/ Violence	Green Measurement	Crime/Violence Measurement	Unit of Analysis	Theoretical Grounding
Kuo and Sullivan (2001b)	Chicago, Illinois, USA	Cross-sectional ordinary least squares regression	Trees and grass	Property crimes: (simple theft, vehicle theft, burglaries, and arson). Violent crimes: (assault, battery, robbery, and homicide) total crime	Aerial tree canopy photographs, plus ground-level photographs, rated on a 0–4 green scale (0 = *sparse canopy/green*, 4 = *full*) by five student raters	Number of crimes per building	Public housing buildings	Attention restoration theory, Jacob's "eyes on the street" surveillance
Snelgrove, Michael, Waliczek, and Zajicek (2004)	Austin, Texas, USA	Cross-sectional Pearson's correlation coefficients	Vegetation: grass, trees, shrubs, groundcover, plants	Violent crimes: (capital murder, murder, manslaughter, attempted aggravated robbery, aggravated robbery by assault, and attempted robbery by assault). Property crimes: (burglary of a residence, attempted burglary of a residence, burglary of a nonresidence, and attempted burglary of a nonresidence)	NDVI of the entire city of Austin	Severity scale 1–6 (1 = *most severe*, 6 = *least severe*)	Austin city limit boundaries	N/A
Troy, Grove, and O'Neil-Dunne (2012)	Baltimore, Maryland, USA	Cross-sectional ordinary least squares regression	Tree canopy	Density of combined burglary, robbery, shooting crimes, and theft	Tree canopy data: National Agricultural Imagery Program infrared imagery + surface models from light detection and ranging data aggregated to census block	Crime density using spotcrime for 2007–2010 data	Census block group within Baltimore city, County	Jacobs "eyes on the street"
Wolfe and Mennis (2012)	Philadelphia, Pennsylvania, USA	Cross-sectional Pearson's correlation ordinary least squares regression	Tree canopy	Violent crime: (aggravated assault and burglary). Property crime: (robbery and theft)	NDVI aggregated to census tract level	Crime rate per 1,000 residents for 2005	Census tracts	Attention restoration theory collective efficacy

Note. CPTED = Crime Prevention Through Environmental Design; NDVI = normalized difference vegetation index; N/A = not applicable.

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crime in four measures (one total violent crime, one aggravated assault, one gun violence, and one aggravated assault with and without a gun). Further, only one study found an increase in total crime compared with five studies that found a decrease in total crime.

In terms of the focus of research conducted on urban green space, violence, and crime, equal numbers of studies have examined relationships between property crimes and green space and total crime and green space (five studies), while four explored violent crime and green space, two explored nuisance crimes and green space, and only one study explored intimate partner violence and green space. Within types of green space, four studies examined relationships among the density of vegetation, crime, and violence, two studies examined relationships between trees, crime, and violence, and two studies used vacant lots to compare crime and violence before and after greening interventions. More specifically, two studies examined relationships between the density of vegetation and property crimes, two studies examined relationships between the density of vegetation and violent crimes, two studies examined relationships between the density of vegetation and total crime, and one study explored the relationship between the density of vegetation and aggression. Among studies focusing on green interventions, two studies each explored urban green space relationships with property crimes, nuisance crimes, and violent crimes and one study examined urban green space relationships with total crime. Finally, among studies using trees as the predictor of green, one study examined relationships between trees and property crimes and two examined relationships between trees and total crime.

Collectively, three examples of conflicting results in the direction of the relationship between urban green space and crime and violence emerged. Among property crimes, two studies (Branas and Donovan) found that vandalism decreased while another (Garvin) study found that vandalism increased. Because these two studies were a part of the same larger study and measured the same type of green and crime, it is interesting to find conflicting results. However, it is important to note that Garvin's study was much smaller, and because only two vacant lots were compared, they were only able to use unadjusted analyses. In contrast, Branas et al.'s study adjusted for the effects of individual vacant lots that were contiguous to one another, age, unemployment, education, income, race, ethnicity, and poverty.

Another study also found results counter to those found by Garvin. In this study (Donovan), the presence of large trees decreased the number of burglaries, whereas Garvin found increased numbers of burglaries following the greening of a vacant lot. When examining these results more closely, large differences in measurement and scale, in addition to Garvin's unadjusted analysis, likely contribute to variations in findings; Garvin explored a green intervention while Donovan focused on the size of trees. In addition, it is important to note that Donovan also found that *increased numbers* of trees on residential property lots increased burglaries, which supports Garvin's finding.

Finally, results demonstrate conflict in the direction of the relationship between trees and total crime, with Donovan finding that increased numbers of trees on residential property lots increase total crime, while Troy found that increased tree canopy decreased total crime. Once again, however, Donovan had additional results demonstrating that *large* trees decrease total crime. Furthermore, the issue of scale again likely contributes to the explanation of conflict, as Donovan looks at the number of trees on individual residential lots and Troy looked at tree canopy cover over city and county streets. Given other study findings, it is likely that a measure of total crime as an outcome masks some differences among different types of crime when measured separately.

Discussion

This is, to our knowledge, the first systematic review examining empirical, quantitative evidence of relationships between urban green space, crime, and violence in the United States. No limitations were placed on types of green space, crime, or violence in the searches and, subsequently, some variation in outcomes was expected. Research and theories that individually consider crime, violence, and urban green space have rich histories in numerous disciplines but until recently have lacked a public health lens, which is concerning given their demonstrated impact on population health. Hence, this review was carried out with the intention that evidence of relationships between urban green space, crime, and violence will help to inform community and population health interventions and research while also addressing remaining research gaps in violence, crime, and green space literature at large.

Results revealed numerous study variations that impact interpretation and comparison. The majority of existing studies on relationships between urban green space, crime, and violence are cross-sectional. In the future, more longitudinal studies, like Branas et al.'s, should be employed to further understanding of temporal relationships between urban green space, violence, and crime. Furthermore, numerous variations in the unit of analysis create problems of interpretation as "communities" are defined on different scales. Similarly, though studies were limited to the United States and search terms specified urban areas, the cities included in the 10 selected studies represent widespread regional diversity and include the West Coast, South, Midwest, and East Coast. In the future, replications of studies should be conducted to test for differences that may be attributed to varying units of analysis and geographical differences among studies.

Beyond study design, unit of analysis, and study location, numerous variations in study analysis, measurement, and outcomes also exist. Variations in the statistical analysis methods employed, though reflective of the different study designs and purposes, once again make study comparison difficult. Furthermore, while the majority of the studies utilized a type of green space that could fall into categories based on the density of

vegetation, trees, or a greening space intervention, within each category, different measurement tools were utilized and therefore capture different information. Similarly, though crime and violence outcomes mainly fell into property crime, nuisance crime, violent crime, intimate partner violence, and total crime categories, the type and measurement of crime and violence varied within categories. Finally, while Table 1 demonstrates some overlap in outcome directions related to urban green space, crime, and violence (for instance, large trees and high levels of vegetation demonstrate consistent decreases in crime and violence), it also supplies evidence of specific crimes and violence with opposite relationships with urban green space (burglary, vandalism, disorderly conduct, and total crime increased in some studies).

When considering overall outcome results, one can also begin to make some preliminary hypotheses about relationships between urban green space, crime, and violence. To start, studies demonstrated 19 instances of decreases in crime and violence related to green space when compared to 9 instances of increases in crime and violence. Thus existing studies demonstrating empirical evidence of relationships between green space, crime, and violence, strongly suggests that the presence of specific types of urban green space can lead to reductions in crime and violence. In addition, the results supply information on future research directions. For instance, in seven of the nine instances where crime appeared to increase in relation to green space, measures of crime were property crime and nuisance crimes; thus future research exploring relationships between urban green space, nuisance crimes, and property crimes may help to narrow what features of urban green space increase the likelihood of property and nuisance crime. In contrast, among violent crimes and total crimes, there were 12 instances that demonstrated reductions in crime and violence compared to only 2 instances of increased crime and violence, suggesting that increased studies on green space in relation to violent and total crimes may provide important additional insight into causal mechanisms behind reductions in crime and violence related to urban green space.

Another important component of study outcomes in this review is the visualization of where research gaps and research conflicts remain (Table 1). Most obvious are research gaps examining relationships between the density of vegetation and nuisance crimes, trees and nuisance crimes, greening interventions and intrafamily aggression and violence, and trees and intrafamily aggression and violence. In addition, conflicts remain about the direction of the relationship between urban green space and vandalism, burglaries, disorderly conduct, and total decreases in crime. Some of the conflicts may be attributable to one study's inability to adjust analyses, but other conflicts highlight the overall need for increased research to continue to improve understanding of complex interactions between urban green space, violence, and crime.

At this time, it is not possible to draw any overarching conclusions about relationships among urban green space, crime, and violence, but again, existing studies support the idea that urban green space holds great potential to decrease community crime and violence. As aforementioned, although inclusion criteria narrowed down a large number of initial titles culled through searches, widespread variation in study methods and outcomes makes direct comparisons among selected studies difficult. However, the challenges associated with such variations again provide clear implications for future research. To begin, increased standardization in the type of urban green space, crime, and violence considered, the communities studied, and the methodological measurements and type of analysis is needed. As aforementioned, one solution may be to begin to think of relationships among green space, violence, and crime as multilevel and to employ social ecological models so as to better understand the separate individual, interpersonal, community, and structural impacts and tailor interventions accordingly. Alternatively, or, in addition to increased standardization and employment of multilevel models, replications of the studies in which green space demonstrated effective decreases in crime and violence should be conducted in different locations to determine whether geographic or population demographic variation significantly impacts the results.

In addition to refining and improving research designs and methods, researchers should begin to standardize what variables are controlled for, to help further understanding of the amount of variance accounted for by green space, and to better determine causative agents. This is especially important given that among the studies included, only one study controlled for variables to determine a health-related causal pathway by a specific mechanism (Kuo & Sullivan, 2001a). The other studies relied on historical social and crime theories or mental functioning pathways but did not actually determine a causal agent. Hence, improvement in understanding variable interplay and establishing scientific evidence of causal pathways is also needed.

Other limitations specific to this review include the small number of studies reviewed (10), which adds to the difficulty in drawing conclusions and making generalizations about relationships among urban green space, violence, and crime. As a result, even if methodological characteristics and outcomes were more consistent, results of studies demonstrating relationships between urban green space, crime, and violence would remain preliminary and interpretation and generalization of results would need to remain conservative. Hence, increasing the number of studies along with standardizing study design and measurements will be imperative to improving understanding of relationships among urban green space, violence, and crime.

Beyond review limitations caused by the small numbers of studies and a lack of standardization among studies, there is much diversity in the disciplinary backgrounds of researchers working on this research topic. Although interdisciplinary and transdisciplinary research collaborations to address interdisciplinary research questions, such as this one, are strongly promoted by the most prominent health institutes in the United States, the review brought forth evidence of poor communication and awareness of researchers doing complimentary work but in different disciplines. This is an important finding as

increased, interdisciplinary collaboration could enhance the research understanding and would allow for researchers to standardize methods, measurement, and analyses moving forward as well as to determine best practices for study design, measurement, and methods. Already this review has highlighted the plethora of theories from different disciplines on which studies can build and has additionally added a critical public health lens to understanding relationships among green space, violence, and crime.

Interestingly, the review also highlighted that one of the factors that likely contributes to a lack of collaboration among researchers from different disciplines are limitations in the current organization of databases. Green space, violence, and crime transcend numerous disciplines and thus to search for journals in databases organized by discipline or journal inherently limits results. As aforementioned, the authors of this review hoped to employ google scholar, a database with a different search strategy that does not limit results by discipline or journal, but based on limitations in importing articles in bulk and the inability to limit searches to journal articles, it was not feasible at this time. However, recent studies utilizing google scholar suggest that with time, google scholar could emerge as an important, sophisticated tool for literature reviews on interdisciplinary topics and may eventually be utilized as the sole search engine for systematic literature reviews at large (Anders & Evans, 2010; Gehanno, Rollin, & Darmoni, 2013; Noubakhsh, Nugent, Wang, Cevik, & Nugent, 2012; Younger, 2010).

Moving forward, increased communication and collaboration among researchers conducting studies related to relationships between urban green space, crime, and violence will be crucial and will help to improve the quality and rigor of future research. This is important as to date, there is only one longitudinal study on green space, crime, and violence, and there is variation in the quality of existing studies. Also disconcerting are direct conflicts that emerge among some of the studies in how findings and outcomes are interpreted. For example, in one study, the number of police calls was the specified crime outcome (Crewe, 2001), whereas an author of a different study hypothesized that an increase in police calls following a greening intervention can be attributed to increased social cohesion and community investment in maintaining neighborhood safety (Branas et al., 2011). Hence, increased communication among researchers will also help to decrease current conflicts in study interpretations and comparison in addition to improving the overall quality of research on urban green space, violence, and crime.

Despite clear limitations on what can currently be concluded about evidence of relationships between urban green space, crime, and violence, it is also important to remain cognizant of the very recent nature of the studies and the opportunities for progress in research through increased understanding of where challenges lie and limitations currently exist. Three of the selected studies were published in 2012, one in 2011, and one in 2010, highlighting the fact that half of all studies included in the review were published in the last 3 years. This demonstrates the innovative nature of the studies as well as momentum in this interdisciplinary topic. Hence, moving forward, urban green space, violence, and crime collaborations could serve as examples of how other interdisciplinary questions and collaborations can effectively be addressed.

Conclusion

Currently, there are too few studies, too much variation in study methods and outcomes, too much conflicting evidence of relationship directions, and not enough understanding of causal pathways to make broad, conclusive statements about relationships among urban green space, violence, and crime. In addition, it is unlikely that green space alone will suffice as an intervention to community violence and crime, both of which have vastly complex roots. Nevertheless, preliminary research examined in this systematic literature review demonstrated overwhelmingly positive associations between urban green space and decreased violence and crime. In addition, the findings presented offer important insight into current strengths and challenges of existing studies and highlight remaining research gaps. Further, results of this systematic literature review present numerous opportunities and suggestions of how to improve understanding through future urban green space, violence, and crime research. Improvements in study design, standardization of study methods and measurements, employment of multilevel models like the social ecological model, and increased numbers of studies will further understanding of relationships among urban green space, crime, and violence, and support and inform future urban green space interventions intended to serve as a place-based solution to improve community and population health.

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