

## Nature-Based Strategies for Improving Urban Health and Safety

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**ABSTRACT** *Place-based programs are being noticed as key opportunities to prevent disease and promote public health and safety for populations at-large. As one key type of place-based intervention, nature-based and green space strategies can play an especially large role in improving health and safety for dwellers in urban environments such as US legacy cities that lack nature and greenery. In this paper, we describe the current understanding of place-based influences on public health and safety. We focus on nonchemical environmental factors, many of which are related to urban abandonment and blight. We then review findings from studies of nature-based interventions regarding impacts on health, perceptions of safety, and crime. Based on our findings, we suggest that further research in this area will require (1) refined measures of green space, nature, and health and safety for cities, (2) interdisciplinary science and cross-sector policy collaboration, (3) observational studies as well as randomized controlled experiments and natural experiments using appropriate spatial counterfactuals and mixed methods, and (4) return-on-investment calculations of potential economic, social, and health costs and benefits of urban greening initiatives.*

**KEYWORDS** *Urban nature, Green space, Place-based interventions, Public health, Crime*

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There is growing support of place-based programs to help prevent disease and promote public health and safety.<sup>1-5</sup> This movement is largely motivated by increasing findings that public health interventions targeted at individuals or behaviors have limited effect on health and safety outcomes at a population scale.<sup>6</sup> For example, educational programs that promote behavioral change among very specific, targeted population groups may not impact broader societal issues such as the actual contexts within which unhealthy behaviors like tobacco use, lack of exercise, poor diet, distracted driving, and violence occur.<sup>7-9</sup> Moreover, programmatic impact is rarely sustained beyond the small study populations that are targeted. When funding ends, program impact thus also often ends unless, in very rare instances, the program itself somehow becomes institutionalized or part of a larger social norm.

Place-based programs rest on increasing evidence that in addition to biological and individual attributes, *everyday environments* have a potentially strong and

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lasting influence on health and safety.<sup>10–13</sup> Environmental factors play a role in health behaviors and health outcomes,<sup>14</sup> and unequal access to healthy environments contributes to health inequities.<sup>15</sup> Residents of under-resourced neighborhoods are more likely to experience exposure to substandard housing, noise, air pollution, violent crime and environmental hazards.<sup>16</sup> Research has established many negative outcomes associated with such disadvantaged neighborhood conditions.<sup>12,15,17,18</sup>

Place-based interventions have the potential to influence a “culture of health” that supports healthy lifestyles at home, work, play, and in the places in-between,<sup>2</sup> and that impacts population-scale health and safety. Moreover, the influence of place-based changes often occur without asking would-be beneficiaries to change their habits, adhere to treatment regimens, or remember classroom training they may have once received.<sup>1</sup> These interventions echo early movements to address public health crises by, for example, improving tenement housing conditions or reducing urban pollution and improving sanitation.<sup>19</sup> Today’s place-based programs aim to improve health by changing environments, both social and physical; examples include improving nutrition and reducing obesity by increasing access to healthy food,<sup>20</sup> decreasing smoking by reducing tobacco advertisements and availability,<sup>21</sup> or reducing violence and crime by modifying opportunistic environments for offenders.<sup>22</sup>

Place-based initiatives involving urban nature or green space provide a particularly powerful opportunity to affect health and safety. Examining the impact of green space on health and safety is relevant to scientists and policymakers, some of whom have led a recent resurgence of urban greening initiatives, largely in response to concerns about global climate change, clean water and energy shortage, and endangered species.<sup>23–25</sup> Yet, while urban sustainability movements and science have claimed that improved public health is a value-added benefit, very little research has been conducted establishing these relationships in a meaningful, actionable way.

In this review, we focus on urban areas and in particular legacy cities affected by population decline and resulting urban blight. We then explain current understandings of place-based influences on public health and safety from the vantage point of economically disadvantaged urban contexts. We focus on nonchemical environmental influences that are related to urban abandonment and blight. We then review findings from studies of nature-based environmental interventions regarding impacts on health, perceptions of safety, and crime. Based on our findings, we present guidelines for research to further characterize if and how green space could be a tool to improve health and safety in urban areas.

## **PLACES AND HEALTH: URBAN BLIGHT**

Urban blight is a predominant environmental condition in many US cities, especially in many low-socioeconomic status (low-SES) neighborhoods. One component of urban blight is vacant properties, which are increasing in number in many US cities.<sup>26</sup> Dilapidated buildings and abandoned lots are the main forms of vacant properties. They are iconic signs of declining population and resources in legacy cities affected by out-migration, economic restructuring, and housing foreclosures.<sup>27–29</sup> Postindustrial cities have experienced rapid declines in manufacturing jobs, further exacerbating residential flight and the growth of vacant properties. For example, around 2010, Philadelphia, PA, had over 40,000 vacant properties,<sup>30</sup>

Youngstown, OH, had approximately 31 % vacant properties,<sup>31</sup> and Detroit, MI, had a reported 26 % residential property vacancy rate.

Abandoned buildings are often easily accessible for those engaging in illegal activities such as drug use and prostitution. As parcels of land, vacant lots are often sites of illegal dumping of materials such as construction debris, chemicals, oil and gas products, tires, and vehicles.<sup>32</sup> According to residents, vacant properties invite trash, rodents, and crime.<sup>33</sup> Moreover, it can be impossible for residents to avoid blighted, unchecked spaces within their daily routines making unhealthy exposure to these properties a persistent problem that may have cumulative effects over the course of a lifetime.

A growing body of research suggests this exposure to blighted spaces negatively impacts multiple aspects of health.<sup>34–36</sup> One study that involved interviews with residents found that living among vacant lots impacts community well-being and physical health.<sup>33</sup> Studies have also found associations between presence of vacant properties and physical health indicators including rates of drug-dependence mortality,<sup>37</sup> teen births,<sup>38</sup> sexually transmitted disease,<sup>39</sup> premature mortality,<sup>40</sup> and cardiovascular disease.<sup>41–43</sup> They also increase the risk of fire.<sup>44</sup>

These hazards also have documented impacts on mental health. Visual environmental cues, or psychosocial hazards, such as crime, substandard housing or abandoned properties, graffiti, and trash dumping can evoke feelings of fear.<sup>45</sup> Perceived disorder is associated with higher levels of anger, anxiety, and depression.<sup>46–51</sup> Nearby residents have indicated that living among vacant lots triggers stress and anxiety.<sup>33</sup> Residents who experience fear or negative emotions regarding their neighborhood can be subject to more stress than those who do not.<sup>15,52</sup>

Recently, studies have investigated chronic stress or stress dysregulation as a physiological pathway linking environments to health outcomes.<sup>53,54</sup> For example, neighborhood blight has been shown to trigger a biological stress response.<sup>36,55–57</sup> In response to an external stressor, the body activates a neuro-hormonal cascade that results in a “fight or flight” response. While this response is protective in acute situations, repeated exposure leads to permanent downstream inflammatory changes and dysregulation of cardiovascular, neurological, and endocrine systems.<sup>58,59</sup> The negative health impact from these changes accumulates over a lifetime for those who are repeatedly exposed to stressors in their home or neighborhood surroundings.<sup>60–62</sup>

## **URBAN GREENING AS PLACE-BASED PUBLIC HEALTH INTERVENTION**

Urban nature or green space has played a fundamental role in urban planning. Urban greening initiatives have taken many forms over time, from large park planning or preservation to pocket-park movements,<sup>63</sup> street-tree planting, storm water management, and habitat restoration initiatives.

While recent greening initiatives are often regarded as solely ecological pursuits, the connection between urban nature and public health is reemerging within science and policy. A growing body of evidence supports an association between greening and human health. In recent years, a number of papers have been published that review the body of evidence of association between nature and human health,

broadly covering physical and mental health outcomes,<sup>64–67</sup> as well as mechanisms and parameters of association.<sup>66,68</sup>

With one major exception,<sup>67–69</sup> these studies and reviews do not focus on the relationship between nature or nature interventions and health in low-resource communities. Yet, it is known that socioeconomic status, including income and education, is strongly associated with poor health outcomes, including higher rates of cardiovascular disease, mental health problems, and even death.<sup>70–72</sup> The impact of poverty on health begins in childhood and the effects are long-lasting, even in adults that escape poverty.<sup>73</sup> In addition, in the US, life expectancy is lower among those born in low-SES counties compared to those in more wealthy counties.<sup>74</sup> Place, and the natural aspects of place, could be an important ingredient in the relationship between poverty and health.

The mechanisms by which green space affects human health are not well understood; however, studies have explored pathways including pollutant exposure,<sup>75</sup> biodiversity,<sup>76</sup> stress, and physical and social activity.<sup>66</sup> In the context of urban blight, a limited number of studies emphasize possible mechanisms of physical activity, stress, and social cohesion.

Many of these studies suggest that improving access to greened outdoor amenities can counteract declining physical activity levels in postindustrialized urban areas. Two prior reviews have focused on evidence of the role of nature in changing rates of physical activity as a mechanism to improve health.<sup>64,77</sup> While numerous studies on the link between green space and physical activity exist, many use cross-sectional ecologic study designs and find nonsignificant or negative associations.<sup>64,66,78</sup> However, one quasi-experimental study of a vacant-lot greening program in Philadelphia, PA, found an association between greened vacant lots and increased physical activity.<sup>79</sup>

Green exposure has also been shown to prevent and mitigate stress, anxiety, and depression,<sup>80–83</sup> especially in urban environments.<sup>81,84,85</sup> Access to green views has been associated with improved mental health in general<sup>86</sup> and more specifically has been shown to reduce mental fatigue and improve coping with stressful settings.<sup>87–89</sup> Spending time in a garden or nature has been shown to be an effective therapy for stress-related mental health issues (i.e., nature-based rehabilitation).<sup>90</sup> In a blighted urban environment, the vacant-lot greening study mentioned above found decreased levels of self-reported high stress around newly greened vacant lots.<sup>79</sup> In addition, a small randomized trial found decreased ambulatory heart rate, as a dynamic measure of stress, among participants who walked in view of “clean and greened” vacant lots compared to participants who walked in view of untreated vacant lots in their neighborhood.<sup>91</sup>

Social isolation is a strong predictor of mortality and morbidity.<sup>92</sup> Green spaces may also affect health by providing spaces for interaction and shared interest, thereby promoting social capital and cohesion.<sup>93–96</sup> Density of urban tree canopy has been found to be a predictor of social capital.<sup>96</sup> In a public housing setting in Chicago, residents living in areas with green common space reported more use of common space and more social cohesion compared to those living in a barren, ungreen areas.<sup>93</sup>

## URBAN GREENING AND PUBLIC SAFETY

Municipalities and their constituents are also hopeful that greening programs will reduce crime that is often associated with blight and structural inequities, as well as

help residents feel safer. A growing number of studies have investigated the relationship between urban green space, crime, and perceptions of safety. These studies have employed a wide variety of research design and analysis techniques, units of analysis, and outcome measures, have been conducted in a variety of locations, and have produced mixed results.<sup>97</sup>

Regarding perceptions of safety, in some cases, green space and vegetation in urban locations have been associated with increased fear of crime.<sup>98,99</sup> Some people may actually avoid urban green spaces because they believe these locations are gang hang-outs or places for illegal substance use.<sup>98</sup> Some studies have speculated that low-lying trees and shrubs decrease line of sight, hide potential attackers, and block victims from escaping if the need arises.<sup>99,100</sup>

Other evidence suggests, however, that nearby residents may associate urban green space with safety. In a randomized controlled trial of vacant-lot greening, residents living near vacant lots that were turned into green space felt significantly safer compared to those living near vacant lots that were not made into green space.<sup>101</sup> In another natural experiment, green space in a public housing development was associated with residents' increased sense of personal safety.<sup>93</sup>

In addition to changes in perceptions of safety, multiple studies have examined the effects of urban greening on actual crime. Dense vegetation has been shown to promote crime by providing criminals a place to hide themselves or illegal goods.<sup>100,102,103</sup> In contrast, emerging evidence suggests that urban green space may be associated with lower rates of crime. Vegetation abundance has been linked to reductions in violent crimes, property crimes,<sup>104</sup> assault, robbery, and burglary.<sup>105</sup> Larger crown spreads of street trees and residential-lot trees have been associated with fewer total crimes, property crimes, and vandalism.<sup>106,107</sup> A natural experiment in a public housing development showed that more vegetation was associated with decreased violent and property crime.<sup>104</sup>

In one quasi-experimental study, gun violence was significantly reduced around previously vacant land that had been transformed to well-maintained green space trees.<sup>79</sup> The authors postulated that cleaning and greening physically decreased opportunities for hiding guns and other illegal activity by removing uncontrolled growth of weeds and buildup of large trash items on vacant land.<sup>79</sup>

In addition, there is evidence that temperature moderation could be a pathway by which vegetation affects crime. Many cities are subject to the urban heat island effect, where pervasive impervious surfaces elevate temperatures, which has been shown to increase resident discomfort. Relationships between temperature and both property<sup>108</sup> and violent crimes<sup>108</sup> have been found. Increased tree canopy cover can mitigate the urban heat island effect,<sup>109</sup> and, as such, vegetation could play a role in the relationship between heat and crime.

The disparate findings on urban green space, perceptions of safety, and actual changes in crimes suggest that not all green space is the same. Factors such as the type of vegetation, the maintenance of the vegetation, and the context within which vegetation grows may play a role in perceptions of safety and actual crime.

First, the *type* of vegetation and resulting degree of view obstruction may be important in determining its impact on safety perception. For example, participants evaluating vegetation in a public housing court yard reported decreased sense of safety with view-obstructing trees (shorter, low-lying trees) but increased sense of safety for trees that did not block views (e.g., high canopy trees).<sup>110</sup> Vegetation type may also be important in determining impact on actual crime. For example, one study found that small view-obstructing trees were associated with increased

property crime and burglary on single-family residential properties.<sup>106</sup> However, in the same study, taller trees and street trees were associated with decreased violent and property crime.<sup>106</sup>

Second, *unmaintained* green space that falls into disrepair may discourage use by community members and promote illegal activity.<sup>110</sup> One study found that images of open, mowed areas with proximity to streets and well-maintained areas incited feelings of security. Features associated with insecurity were densely forested areas, graffiti, and buildings that appeared vacant.<sup>111</sup>

Finally, the *context* of urban green space may be important in determining the impact on safety perceptions. For example, in a study of over 80,000 people in the Netherlands, urban green space was associated with increased feelings of safety, except in the most dense urban areas.<sup>112</sup> The context of greening and greened spaces may also affect actual crime. One study found that increased tree canopy cover was associated with reduced incidents of shooting, theft, robbery, and burglary especially on public lands.<sup>107</sup> Another quasi-experimental study of the effects of green stormwater infrastructure installation found reduced narcotics possession around greened sites (mostly on public land) after construction compared to control locations.<sup>113</sup>

## OPPORTUNITIES FOR STUDY AND ACTION

Public administrators and their partners require policy and program solutions to interrelated problems of urban poverty, abandonment, blight, poor health, and lack of safety. Making basic structural changes to neighborhood environments potentially offers a promising and sustainable solution to these problems.

However, more research on high-priority, policy-relevant questions is needed to establish causal mechanisms between places, nature-based interventions, and health and safety. For example, what attributes of green space, including size, location, type of vegetation, and level of maintenance mostly affect health and safety? How much and what type of exposure to green space are needed to achieve positive outcomes for the general population or for high-risk population subgroups? How exactly does green space act to influence community interaction and cohesion? A research agenda that answers these questions will need the following: (1) refinement of measures of green space, health, and crime; (2) interdisciplinary and cross-sector collaboration; (3) mixed-methods research and experimental research that employ appropriate spatial counterfactuals (i.e., control groups) and that study observed or investigator-initiated place-based changes over time; and (4) return-on-investment calculations of the potential economic, social, and health costs and benefits of urban greening initiatives.

## REFINEMENT OF MEASURES OF GREEN SPACE, NATURE, HEALTH, AND SAFETY FOR CITIES

An advanced understanding of the relationship between nature, health, and crime will require refinement of the ways in which we measure exposure to green space and nature, especially in places like cities where the environment is dominated by built structures. First, the way in which green space is measured can have an effect on statistical associations found in epidemiologic studies.<sup>114</sup> Prior studies have largely used coarse measures of nature or greening.<sup>97</sup> Aggregate or broad measures of urban nature such as satellite imagery of urban tree canopy assessments<sup>115,116</sup>



often provide a landscape-level measure of green space at isolated points in time. However, they are rarely able to capture microspatial and temporal variation at the local level. More site-specific measures are needed, such as georeferenced information about tree-plantings or removals, parcel, lot, or yardview greening initiatives, and other projects such as green stormwater infrastructure installations. In addition, to date, no studies have tested for effects of specific species of trees on surrounding health and/or safety.

More research is also needed to distinguish the mere presence of green space from actual exposure.<sup>68,117</sup> For instance, percent of green cover within a residential area is a common measure,<sup>85,118</sup> although this measure may not reflect actual exposure to green space. Adults tend to spend between 60 and 70 % of their time at home<sup>119</sup> and the rest of their time at a work or other locations. Development of individual-level, mobile space-time measurements of green exposure, for the purpose of developing dose-response relationships and accurately measuring exposures over the course of daily activities, is necessary. Studies that measure time-activity or time-event to assess exposures and responses, such as those developed for the study of air pollution or violence,<sup>119,120</sup> could prove to be useful models.<sup>121</sup>

More specific health behavior and outcome measures are also required. Beyond survey data regarding physical and mental health, well-measured factors that predict future cardiovascular and metabolic health risks such as weight, blood pressure, blood glucose, hemoglobin A1c, and cholesterol should be measured over time and place. In addition, it is important to understand how residents react when using newly developed green space. Physiologic mechanisms of environmental influences on health are also important but understudied. Physiologic markers of acute stress such as heart rate, blood pressure, and cortisol levels are needed to understand how greening may impact cardiovascular and metabolic health outcomes.<sup>122</sup> These measurements have predominantly been used in laboratory settings but could increasingly be measured with residents in and around their native environments, especially in lower-resource or blighted environments.<sup>123,124</sup>

A range of relevant safety perception outcomes associated with urban green space and greening are also needed. Studies evaluating the association between urban green space and crime have traditionally used coarse crime measures derived from administrative records, such as total crimes, violent, and property crimes. Few studies examine relationships between green space and more disaggregated crime classifications. In addition, research would benefit from direct measurement of perceptions of safety and fear of crime, and possible mediators such as social and built environment characteristics and mental health. It would be useful to directly observe the activity that takes place in a green space on different days of the week and different times of day, perhaps in a semi-continuous way through technology such as time-lapse photography. Not all crimes are reported to the police, and direct observation through the use of infrared cameras, for example, could also allow discrete observation while preserving anonymity for users of these public spaces.

### **INTERDISCIPLINARY AND CROSS-SECTOR COLLABORATION FOR POLICY-RELEVANT RESEARCH**

Developing studies that explore the relationship between greening, public health, and safety will require expertise from multiple fields such as environmental science, public health, epidemiology, medicine, anthropology, psychology, and criminology. In addition, policy-relevant research will require collaboration with community

organizations and policy makers who have an influence on urban greening initiatives.<sup>125</sup> Developing relationships with local stakeholders is vital to designing locally relevant nature-based experimental studies, identifying locations suitable for study, and creating buy-in. It will also be necessary to develop partnerships with agencies or organizations that collect health or crime data, such as police departments, public health departments, health centers, or hospitals.

Previous studies have been conducted in both the USA and internationally.<sup>126</sup> It will also be important that future studies include small, medium, and large urban areas in both developed and less-developed countries. The types of urban green space that would benefit a large city in a developed country may be different than in a medium-sized city in a less-developed country.

### EXPERIMENTAL AND MIXED-METHODS RESEARCH

With a few exceptions,<sup>79,91,101,104,127-129</sup> prior studies have not applied experimental or quasi-experimental approaches in testing whether urban greening affects health and safety and therefore have limited ability to establish causal mechanisms.<sup>64</sup> Despite implementation challenges and longer study periods, new studies should aim to provide the highest level of evidence through randomized controlled trials. If the scientific endeavor to study greening, nature, and health is to achieve a reasonable level of credibility among scientists and policymakers, some (although not most) studies will need to involve randomized trials. In this way, future studies, including randomized trials, would benefit from employing appropriate spatial counterfactuals (i.e., control groups) and studying observed or investigator-initiated place-based changes over time. Care must be taken to explain the need for random assignment and control groups to community-based collaborators, who may see these as unfair and/or object to withholding a potentially beneficial intervention from one portion of the community. These concerns can be addressed by explaining that random assignment is, in fact, a fair way to apply treatments to different spaces (i.e., it is essentially a lottery) and that using a delayed intervention for control groups (i.e., a stepped-wedge approach) is a good way to offer benefits to all interested areas. Here, researchers can capitalize on the fact that government-sponsored greening efforts are often rolled out over months or years in one area and then the next, as a model.

Randomized controlled trials of the physical environment often have their own inherent limitations and are not always possible given various challenges. When this is the case, quasi-experimental and natural experiments could be secondarily prioritized. Longitudinal studies are also important to understand both short- and long-term consequences of urban greening. Mixed methods will also be highly important to fully understand the statistical findings of quantitative studies by leveraging the immense value of adjoining qualitative work. Thus, in addition to quantitative studies, equally rigorous qualitative studies drawing on the methods and expertise of anthropologists and similar qualitative researchers are vital to understanding the exact mechanisms by which greening may affect health and safety outcomes. This type of study can also uncover community members' views of green space and of greening programs, strategies for successful implementation, and intervention effects on communities' social interworkings and micro-social behaviors.



## **RETURN-ON-INVESTMENT CALCULATIONS FOR URBAN GREENING INITIATIVES**

While emerging research is showing health benefits associated with greening initiatives, it is important to also apply a critical lens and investigate potential costs, or question who benefits.<sup>69,117</sup> Greening initiatives can range in financial cost, from relatively inexpensive aesthetic treatments, to more costly treatments, for example, that require large engineering installations, or that are costly to maintain. There may be inequities in communities' ability to ascertain such funding, though collaborative relationships and capacity-building can help address this issue. Greening initiatives also potentially bring economic benefits via the addition of construction and maintenance jobs in local communities and neighborhoods, or "green jobs." However, care should be taken to develop and hire a workforce composed of local residents wherever possible.

While some studies are showing reductions in crime in the immediate vicinity of greened spaces, few have explored the geographic distribution of benefit, or whether crimes are merely being pushed away, thereby negatively impacting other areas. And finally, the negative aspects of gentrification processes must be considered and the possibility that greening initiatives could serve to exacerbate forced out migration for long-term residents as well as social disadvantage or health inequalities.<sup>130</sup> It is therefore important to investigate whether health and safety benefits are occurring and remain, with existing residents, rather than inciting unwanted, and possibly unhealthy, neighborhood transition. In short, it is important to consider a full range of costs and benefits in order to fully calculate the returns-on-investment that greening and nature-producing interventions may produce so that they can be appropriately compared with other types of interventions. If found to have high returns-on-investment, which can be hypothesized as being the case given their often very low costs and numerous benefits, greening and nature-based strategies will be much more rapidly brought into use and scaled up to many more locations than simply those that served as scientific study sites.

## **CONCLUSION**

There are opportunities for research that offer better scientific evidence of the potentially powerful effect that place-based programs can have on population-wide public health and safety, and on reducing health inequalities exacerbated by blighted neighborhood conditions. As a modification to the physical environment, urban greening could have a large population impact that is less dependent on the actions of individuals.<sup>7</sup> Prioritizing urban greening as a research priority for the public health community and policymakers could help to reduce health disparities and improve public health and safety.

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