



Gender Differences in Impacts of Place-Based Neighborhood Greening Interventions on Fear of Violence Based on a Cluster-Randomized Controlled Trial

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Abstract Maintained green space in underserved urban neighborhoods may be an important environmental pathway to improving community health and safety, though effects may vary across population subgroups and by time of day. We examined survey responses from 442 participants (178 men and 264 women), living near vacant lots in a cluster-randomized controlled trial of a cleaning and greening intervention, on perceived safety during the day and at night. At the intervention sites after the intervention, only men reported feeling less unsafe during the day. Women reported more fear, and men reported less fear, after the intervention, although these results and tests for effect modification were not statistically significant. The clean-and-green intervention may have allayed fears for men during the day and

supported their ease of movement throughout their neighborhoods. However, at night, it may have had the opposite effect on women. Though our study was under-powered, not designed to test associations stratified by gender, directions and magnitudes of associations differed substantially, indicating a need for further investigations into potential gender differences in the benefits of green space, to inform and better tailor interventions to improve perceived safety for all.

Keywords Green space · Vacant lots · Fear of crime

Introduction

Recent scientific evidence demonstrates that access to green space in urban communities is associated with positive health and safety outcomes such as reductions in violence, infant mortality, and improvements in physical activity. [23] These findings suggest that creating green space in underserved urban environments may be one pathway to improving community health and safety. A recent citywide cluster-randomized controlled trial of vacant lot greening found significant reductions in crime after the intervention, particularly for neighborhoods with income below the federal poverty line. [5] In addition to reducing crime incidents, participants living near cleaned-and-greened vacant lots reported significant reductions in perceived neighborhood crime, vandalism, and feelings of depression, and significant increases in the

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use of outside spaces for relaxing and socializing compared to residents living near blighted vacant lots. [5, 37] These results further support the idea of maintained green space as a means for improving community health and safety.

It is unclear, however, whether these benefits are evenly distributed across demographic groups. A longstanding body of social science literature indicates that perceptions of safety in urban spaces differ dramatically between women and men. [17] In general, women experience fear of crime more than men do. [13] Women's fear of crime varies by age, race, and class status and can be attributed to differential perceptions of vulnerability [35] and past victimization.

Fear of rape and sexual assault may increase women's fear of crime in general. [11] Evidence also indicates that women, especially in urban settings, substantially re-structure their behaviors based on this fear. [18]

Some researchers [35, 36] argue that social factors and physical location influence fear of crime in ways that are dependent on gender. For women, other aspects of social status can also affect their sense of fear and vulnerability. [27] For example, older women often feel more vulnerable than young women in part due to subordinate socio-political status. [27] Differences in vulnerability reported between women and men could also be due to the fact that men are socialized not to express feeling afraid. [40]

Men's and women's fear of crime can vary differently by time of day. Among a sample of Baltimore residents, there was a significant direct effect of gender on both daytime and nighttime fear of crime, with greater fear for women, especially at nighttime. [41] Among college-aged women, fear of rape is especially heightened at night compared to daytime. [12] Fisher and Sloan [12] also found that college women who engaged in protective measures (for example, carrying an instrument for defense, always walking with someone else, or avoiding perceived dangerous areas) had greater fear of crime than women who did not. Other personal factors such as race and age may interact with gender in perceptions of safety. Also among a sample of college students regarding fear on campus, Fox et al. [13] found that prior victimization and race significantly predicted daytime fear on campus for men and women, while race was a significant predictor of fear for men but not women at night, and

prior victimization did not influence fear on campus for men or women. [13]

The influence of physical location on fear of crime [33] may also manifest differently for women versus men. For women, while familiarity with neighbors can increase feelings of safety, experience of public harassment (esp. of a sexual nature) can decrease perceived safety, especially at night. [35] While presence of people can signal safety, it could be that men feel less threatened by the presence of strangers than women do. [35] Neighborhood social disorder and occurrence of serious crime have been found to increase women's more so than men's fear of crime. [36] Clifton et al. [9] found that among Maryland residents, presence of neighborhood seating was negatively associated with women's walking frequency, and the authors hypothesized that the reason could be that women viewed loitering around seating as threatening. On the other hand, environmental design features such as bright lighting can increase perceptions of safety, especially for women. [7]

Vacant land is a major part of the landscape of deindustrialized cities. Like many deindustrialized cities, Philadelphia experienced the effects of population decline during the second half of the twentieth century. The city's population decreased from 2,071,605 in 1950 to 1,467,000 in 2005. The neighborhood-level consequence of this population decline was an oversupply of housing. Unoccupied housing over the decades have led to vacant and abandoned buildings and lots. According to administrative records, Philadelphia had 41,257 vacant lots in 2016. [8] Vacant lots, as pervasive features of neighborhoods in cities like Philadelphia, have been found to influence fear of crime among residents. [15]

Likewise, the remediation of these lots may improve sense of safety. Vacant lot cleaning-and-greening can cue social control and reduce perceived safety. Previous research has found that residents report lower fear of crime in response to images of well-maintained grass. [24] Early research of vacant lot greening in Philadelphia found that residents living near intervention sites felt significantly safer and less stressed after the greening. [4, 16] However, vacant lot cleaning-and-greening could have unintended negative impacts including, in some circumstances, acting as a signal of gentrification to some residents which can trigger fears of residential displacement. [31]

Vacant lot cleaning-and-greening interventions may also have a differential effect on safety perceptions for men versus women. Parks and other green spaces within cities have been noted as locations where women often feel unsafe, particularly after dark. [17] A systematic review [38] found that some physical attributes of green spaces provoked fear of crime, including physical disorder and incivilities, poor lighting, poor landscaping, and dense vegetation, while other attributes such as maintained lawns and vegetation, open views, and visible escape routes were associated with lower fear of crime. Females were consistently found to have significantly higher fear of crime in urban green spaces than males. [38]

Fear of crime has been shown to impact both mental and physical health. [25, 30] This increased fear could disproportionately affect women's health and well-being. Fear of crime can constrain women's mobility and physical activity and may cause them to stay home, or avoid certain outdoor places or routes. [20, 26, 34] Beyond mental distress that comes along with fear of crime, [29] avoidance behaviors can increase social isolation and thereby impact mental health. [39] Perceived nighttime safety has been significantly associated with lower physical activity (measured as steps per day) among women but not among men [3] and more chronic health problems over time. [28]

Given this potential for urban green space to hold different meaning as relates to personal safety for women versus men, we aimed to understand the impact of gender differences on perceived safety

by time of day with respect to an urban greening intervention. To do this, we conducted a secondary analysis of the data collected in a prior cluster-randomized controlled trial of vacant lot greening. While residents reported reduced fear of crime after the intervention, we questioned whether these findings held true for women versus men, during the day and at night.

Methods

The data analyzed for this study are part of a city-wide cluster-randomized controlled trial of a vacant land intervention in Philadelphia. [5] This reproducible vacant land intervention (shown in Fig. 1), often referred to as “cleaning-and-greening,” involves clearing debris and planting grass and a few trees. It is carried out by the city of Philadelphia, via the Landcare program of the Pennsylvania Horticultural Society (PHS), a non-profit agency.

The trial was conducted between October 1, 2011, and November 30, 2014. A total of 541 randomly sampled vacant lots, located within 110 clusters, were randomly assigned into three study arms: a control group of 166 lots that received no treatment and remained vacant during the study period, a cleaning-only intervention group of 174 lots where contractors picked up trash and mowed where feasible, and a full greening intervention group of 201 lots that received the clean-and-green intervention. Images of the control, cleaning-only, and full intervention lots are shown in previous publications, for example, Fig. 1 in



Fig. 1 Before and after photos of the vacant lot intervention conducted by the Pennsylvania Horticultural Society (PHS). PHS has provided permission for use of these photos

Branas et al. [5] and Fig. 2 in South et al. [37] Study lots were randomly chosen from all eligible lots, which were designated as blighted by city ordinance. Clusters included all eligible lots within a 0.4-km buffer of eligible index lots. Within each of four geographic city sections, lots were randomly allocated to study arms using a procedure that ensured statistically significant balance of potential confounding variables, including total area of cluster lots, mean distance between cluster lots, number of surrounding vacant lots, resident population, and number of serious crimes. [32] The study intervention lots were initially treated over a 2-month period by landscape contractors, and then received monthly maintenance during the 38-month study period.

Changes in crime and violence were assessed using crime reports collected by the Philadelphia Police Department. In addition, resident perceptions of safety, neighborhood social and environmental conditions, personal health, and well-being were assessed via surveys. The trial was approved by the institutional review board and was registered as an International Standard Randomized Controlled Trial (study ID ISRCTN92582209). All participants provided written informed consent.

We conducted surveys to measure residents' perceptions of individual and neighborhood level health and safety such as fear, trust, disorder, collective efficacy, mental and physical health, and related activities. Surveys were conducted using a door-to-door recruitment method in two waves before the intervention and two waves after. Random sampling began at the residence closest to the geographic centroid of each cluster and then moved in a random direction along the same city block until five participants aged 18 years or older had been surveyed. Surveyors selected one participant per household with the most recent birthday. Surveys lasted approximately 20 min were conducted either in Spanish or in English. Both the survey team and participants were blinded to the study intervention. Each participant received \$25 compensation per survey in the form of bank gift cards. The survey response rate of 47.4% [1] matched or exceeded that of other surveys and allowed us to produce a reasonably representative sample of our target population. [14, 19, 22]

The current analysis addressed the following questions: (1) Do differences in feelings of safety during the day between intervention and control groups vary

by gender? (2) Do differences in feelings of safety after dark between intervention and control groups vary by gender? We conducted analyses of two survey questions relating to residents' feelings of safety around going outside their homes. The first was related to daytime, with binary outcome *Unsafe during Day*: In the past month, did you NOT go someplace in your neighborhood during the day because you felt you would not be safe? The second question related to feelings of safety at night, with outcome *Unsafe at Night*: On a scale from 1 to 10, where 1 means "completely safe" and 10 means "extremely dangerous," how safe has it been to walk around alone in your neighborhood after dark this past month?

While the answers to *Unsafe during Day* were binary (0/1), the answers to *Unsafe at Night* were categorical, ranging from 1 to 10, with 10 indicating feeling more unsafe. Both variables are ordered such that higher numbers indicate lack of safety. In addition, participants self-reported their gender.

Statistical Analysis

We first calculated descriptive statistics of cluster and participant characteristics. We used an *F*-test to indicate statistical difference in these characteristics between cluster arms in the entire, pre- and post-intervention samples separately, using the no intervention group as a reference. We then conducted participant-level difference-in-differences analyses in order to compare survey responses taken near the end of the intervention period compared to pre-intervention (pre- and post-intervention conditions at the control sites and the pre-intervention condition at intervention sites). Our outcome variables were ordinal. We used ordered logistic regression to model the difference in feelings of safety between treatment and control conditions pre- and post-intervention. Regression models (Eq. 1) estimated the association between treatment and a safety-related outcome for participant *i* at wave *t*, (Y_{it}). Each model included a term to indicate intervention arm compared to control study arm (β_1); a pre-post-intervention term (β_2), a difference-in-differences term (β_3); and a cluster-level random effects parameter, ξ_i .

$$Y_{it} = \beta_1 Intervention + \beta_2 Pre/Post + \beta_3 Intervention * Pre/Post + \xi_i \quad (1)$$

We examined outcomes for participants that lived in clusters that received the cleaning-only intervention, the full greening intervention, or any intervention (cleaning-only or full) compared to outcomes in clusters that received no intervention. We first stratified models by gender. In addition, we tested for differences in estimates of feeling unsafe during the day and at night for men and women by adding an interaction term between the difference-in-differences and binary gender variables ($\beta_4(\text{Intervention} * \text{Pre/Post})\#Sex$). We conducted all statistical analyses using Stata, version 15 (StataCorp LLC).

Results

The characteristics of the geographic clusters were balanced across the three randomization arms, and there were no statistically significant differences in total number of study lots, mean number of study lots per cluster, total square footage of study lots, or mean number of residents and Part I violent and property crimes (based on an 18-month baseline period and defined by the Federal Bureau of Investigation's Uniform Crime Reporting Program; Table 1).

Surveys were conducted with 442 participants (178 men and 264 women) in the pre-intervention period and with 433 participants in the post-intervention period. This number includes data from 91 replacement participants. Loss to follow-up (20.6% overall; 21.4% in the intervention group and 18.9% in

the control group) from the pre-intervention sample was due to inability to find participants, or because they refused to participate. We included all participants' data pre- and post-intervention in our analyses. Twelve participants (0.03%) chose not to report their age, and five participants (0.1%) chose not to report their gender. Table 2 shows that of the 442 pre-intervention participants, 149 (33.7%) were assigned to the greening intervention, 145 (32.8%) to the cleaning-only intervention, and 148 (33.5%) to no intervention. Of the 433 post-intervention participants included in the analysis, 144 (33.3%) received the full greening intervention, 143 (33.0%) the cleaning-only intervention, and 146 (33.7%) no intervention.

Across the whole pre-intervention sample ($n=442$), mean (SD) age was 44.2 (15.1) years, housing tenure was 12.7 (14.7) years, 264 (59.7%) were female, and 144 (32.6%) were unemployed (see Table 2). The demographic characteristics of participants, as well as geographic city section, between intervention and control groups were balanced. These characteristics were also balanced across the three randomization arms in the post-intervention sample, in all but percent unemployed (with higher unemployment in the control group).

Counts of survey responses, by intervention group and gender category, are shown in Table 3. Average values for Unsafe during Day and Unsafe at Night for intervention (both cleaning-only and full greening intervention) versus control and pre- versus post-intervention are shown in Table 4. Values for Unsafe during Day ranged from 0 to 1, and average values

Table 1 Cluster characteristics across study arms

	Greening intervention	Cleaning-only intervention	No intervention control
Vacant lot clusters, No	37	36	37
Resident population, mean (SD), people	287.8 (117.5)	297.0 (124.6)	284.9 (130.5)
Crimes ^a , mean (SD), crimes	16.5 (6.4)	18.3 (9.6)	17.1 (8.4)
Total eligible vacant lots, mean (SD), lots	38.3 (25.2)	43.1 (28.4)	38.1 (31.1)
Prior treated lots, mean (SD), lots	6.7 (9.5)	5.3 (9.7)	5.6 (14.1)
Total study lots, No	201	174	166
Study lots per cluster, mean	5.4	4.8	4.5
Study lots total area, ft ² , mean (SD), lots	4,844 (970.2)	4,935 (991.6)	4,872 (1375.7)
Study lots separation, mean (SD), ft	75.6 (85.5)	71.3 (77.3)	73.5 (70.2)

^aPart I violent and property crimes based on the Federal Bureau of Investigation's Uniform Crime Reporting Program
SD standard deviation, No. number

Table 2 Participant characteristics across study arms^a

		Full greening inter- vention	Cleaning-only inter- vention	No intervention control
Participants, no	Pre	149	145	148
	Post	144	143	146
Age, mean (SD)	Pre	43.3 (15.0)	44.2 (15.7)	45.2 (14.8)
	Post	43.6 (14.0)	46.7 (14.6)	46.1 (15.1)
Sex, no. (%)				
Male	Pre	57 (38.3)	54 (37.2)	67 (45.3)
	Post	62 (43.1)	50 (35.0)	56 (38.4)
Female	Pre	92 (61.7)	91 (62.8)	81 (54.7)
	Post	80 (55.6)	93 (65.0)	88 (60.3)
Housing tenure, mean (SD)	Pre	12.5 (14.4)	12.0 (14.2)	13.5 (15.7)
	Post	13.9 (13.6)	12.4 (13.7)	15.0 (15.1)
Percent unemployed, no. (%)	Pre	44 (29.7)	46 (31.7)	54 (36.6)
	Post	35 (24.3)	32 (22.4)	58 (39.7)**
City geographic section	North-northeast	131	128	173
	North-northwest	163	198	97
	South	166	130	147
	West	129	131	182
	Missing	1		0

^aResults from tests of statistical difference with the no intervention group serving as the reference group are indicated by * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$

Table 3 Pre-post-intervention counts of survey responses by intervention group and gender

	Pre	Post
Total responses	817	697
Control group	269	146
Cleaning-only intervention	271	133
Full greening intervention	277	165
Female	494	319
Male	288	153

were lower post-intervention at sites that had received any intervention (1) compared to sites that had received no intervention (either pre or post-intervention (0)). Values for Unsafe at Night ranged from 0 to 10, and the average value post-intervention at intervention sites was 5.49 for the full sample, compared to an averaged value of 5.36 at sites that received no intervention.

Difference-in-differences estimates from ordered logistic regression models, stratified by gender, are shown in Table 5. We found a statistically significant decrease in feeling unsafe during the day from pre- to post-intervention (when considering both the cleaning-only and full greening intervention) among men (OR: 0.22, 95% CI: 0.05, 0.95), but not among women. While none of our estimates for feeling unsafe at night was significant, we found a different direction of effect—a decrease for men, indicating feeling less unsafe, and an increase among women, indicating feeling less safe, after the intervention when considering the cleaning-only, the full greening, or either intervention.

Finally, the estimate for the interaction term of difference-in-differences and binary gender variable was not statistically significant for feeling Unsafe during Day or at Night for any intervention compared to controls. While not statistically significant, odds ratios for Unsafe at Night were consistently above 1.0 for women and consistently less than 1.0 for men—suggesting that women felt less safe at night than men did after the intervention.

Table 4 Average values for Unsafe during Day (ranging from 0 to 1 with 1 being unsafe) and Unsafe at Night (ranging from 0 to 10 with 10 being most unsafe) for intervention versus control, pre- versus post-intervention

	All participants											
	Men					Women						
	Control	Cleaning-only intervention	Full green-inter-vention	Any inter-vention	Control	Cleaning-only intervention	Full green-inter-vention	Any inter-vention	Control	Cleaning-only intervention	Full green-inter-vention	Any inter-vention
Unsafe during Day												
Pre-intervention	0.10 (0.30)	0.14 (0.35)	0.12 (0.33)	0.12 (0.33)	0.10 (0.30)	0.10 (0.10)	0.12 (0.33)	0.12 (0.33)	0.10 (0.30)	0.16 (0.37)	0.13 (0.34)	0.12 (0.33)
Post-intervention	0.08 (0.27)	0.09 (0.29)	0.06 (0.24)	0.06 (0.24)	0.05 (0.22)	0.08 (0.08)	0.05 (0.21)	0.05 (0.22)	0.10 (0.30)	0.10 (0.30)	0.07 (0.26)	0.07 (0.25)
Unsafe at Night												
Pre-intervention	5.48 (2.92)	5.55 (3.12)	5.59 (2.98)	5.58 (2.99)	4.94 (2.79)	5.14 (3.01)	5.39 (3.00)	5.40 (3.02)	5.92 (2.96)	5.79 (3.18)	5.73 (2.98)	5.69 (2.98)
Post-intervention	5.01 (2.68)	5.22 (2.94)	5.49 (2.77)	5.48 (2.79)	4.67 (2.60)	4.28 (2.52)	4.88 (2.50)	4.87 (2.52)	5.27 (2.73)	5.76 (3.03)	5.87 (2.85)	5.84 (2.87)

Table 5 Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) of intervention effect for controls versus the cleaning-only full interventions, pre- versus post-intervention, from ordered logistic regression models stratified by intervention condition and gender, and for the interaction between difference-in-differences term and gender

Outcome	Male OR (95% CI); <i>p</i> -value	Female OR (95% CI); <i>p</i> -value	Interaction OR (95% CI); <i>p</i> -value
Unsafe during Day			
Cleaning-only intervention	0.84 (0.21, 3.40); 0.805	0.53 (0.19, 1.48); 0.224	0.86 (0.27, 2.73); 0.794
Full greening interventions	0.55 (0.11, 2.72); 0.461	0.56 (0.20, 1.58); 0.276	1.00 (0.31, 3.23); 0.995
Both interventions	0.22 (0.05, 0.95); 0.042	0.57 (0.21, 1.55); 0.269	2.05 (0.56, 7.60); 0.281
Unsafe at Night			
Cleaning-only intervention	0.63 (0.79, 2.38); 0.257	1.37 (0.79, 2.38); 0.257	1.51 (0.92, 2.47); 0.105
Full greening intervention	0.78 (0.83, 2.76); 0.175	1.51 (0.83, 2.76); 0.175	1.27 (0.77, 2.12); 0.341
Both interventions	0.87 (0.80, 2.67); 0.215	1.46 (0.80, 2.67); 0.215	1.18 (0.70, 2.00); 0.526

Discussion

Many cities are investing in improvements to community spaces, including vacant lots, as a means to stabilize housing markets and improve residents' health and safety. We aimed to understand gender differences in the impacts of an urban greening intervention on perceived safety by time of day. We analyzed survey responses from men and women living near control and intervention sites, to determine if their perceptions of safety during the day and night changed after the intervention. While we found that men felt significantly *safer* during the day near intervention lots (regardless of intervention type) after the intervention, we found consistent, though non-significant, *decreases* in women's sense of safety after interventions. Though our study was under-powered to detect significant differences between women and men, the direction of effect was starkly different for men versus women, which deserves greater attention. [2] Results indicated that women may have had more fear compared to men after the intervention. The clean-and-green intervention may have allayed fears for men and supported their ease of movement throughout their neighborhoods. On the other hand, it may have had the opposite effect on women at night.

While our study did not test mechanisms for these findings, there are some potential explanations. First, across all responses, there was a statistically

significant increase in reported use of outdoor space, [5] and our findings indicate that men felt safer going outside both during the day and at night after the intervention. Men may have changed behaviors, spending more time together outdoors and in cleaned-and-greened lots. While the intervention did not include formal seating, ethnographers of the original study [5] reported that the fence was frequently used as informal seating, and previous research has found that observing males congregate in spaces, including urban green spaces, can increase fear of crime among women. [21, 38] While young men often lower their perceived risk of victimization by traveling in groups, this behavior can increase young women's perceived risk. [10]

A study in Philadelphia [6] found gender differences in perceived safety as it related to a large city park. While men carried a general fear of victimization, environmental variables were not influential on their fear, except that they wanted to see an escape route. Vacant lot cleaning-and-greening could increase men's feelings of safety by improving sight lines. Young women's fear was influenced by a wider variety of factors including personal experience, community stories, gender socialization, and environmental cues. Women's fear negatively impacted their mobility and reduced their time in a park, especially at night, without accompaniment (typically male).

Limitations of the cluster-randomized controlled trial include the fact that long-term impacts were not assessed. There was a seasonal imbalance between the pre-intervention (one summer season and three winter seasons) and post-intervention (two summer seasons and two winter seasons) periods, which could influence crime perceptions. We did not account for season in our statistical models, which may subjectively affect people's perceptions of safety and what "night" means. However, this imbalance and potential seasonal affect was experienced equally by the intervention and control groups. We included survey responses from replacement participants, which could influence difference estimates between pre- and post-intervention responses. However, participant characteristics were similar and balanced between intervention and control groups except in unemployment. In addition, the study was not powered to detect differences separately for men and women. Further mixed-method research, powered appropriately, is needed to explore specifically for men and for women the potential influence of vacant lots and vacant lot maintenance on feelings of safety. For example, research methods from social and environmental psychology could be used to assess reactions to various social and physical characteristics of vacant lots.

Conclusions

Creating green space in underserved urban environments may be one pathway to improving community health and safety. Prior analyses found a statistically significant decrease in observed crime and violence after the intervention. However, the intervention may not have improved perceptions of safety across social groups. Our examination of survey responses from men and women living near vacant lots that were part of a cluster-randomized controlled trial of a cleaning-and-greening intervention found that only men felt significantly more safe during the day. The clean-and-green intervention may have allayed fears for men, although we consistently observed associations in the opposite direction for women, suggesting that women felt less safe after interventions, although our study was under-powered to test differences by sex. Further investigations to explicate these differential effects could inform tailoring of such programs to increase feelings of safety for all.

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