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Physical environment and violence perpetration among male youth in Pittsburgh: A spatial analysis

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Abstract

Purpose: Examine associations between features of the built environment and violence perpetration among male youth.

Methods: We enrolled 868 male adolescents, ages 13-19 years, as part of a violence prevention study in 20 low-resource neighborhoods in Pittsburgh, PA. Exposure to built environmental features was defined using participants' neighborhood study site. Violence perpetration was measured by three survey items: physical fighting, threatening someone with a weapon, and injuring someone with a weapon. Logistic regression models examined associations between each environmental feature and violence perpetration.

Results: Better neighborhood walkability was associated with significantly lower odds of fighting (adjusted odds ratio (AOR)=0.86, 95%CI:0.76-0.99). Alcohol and tobacco outlets were associated with slightly lower odds of violence perpetration (AORs=0.90-0.96).

Conclusions: This work extends previous studies from large urban centers to a mid-sized city context and suggests that walkable neighborhoods create opportunities for social interactions and may serve as a protective factor in youth violence.

Keywords

violence prevention; environment; spatial distribution; adolescent

Competing interests: None declared.

Introduction

Male youth in lower-resource neighborhoods experience a disproportionate burden of violence,(1) negatively affecting health outcomes and increasing risk of injury and incarceration.(2) In 2017, 30% of male high school students reported being in a physical fight in the past year and 24% reported carrying a weapon in the past month.(3) Violence experiences during adolescence can lead to further violence involvement later in life.(4)

Emerging research suggests environmental contexts in large urban centers may shape violence risk. A body of evidence has demonstrated that features of the built environment – like vacant properties, pedestrian infrastructure, and access to green space – may influence rates of crime and violence.(5-7) Alcohol and tobacco outlets have also been shown to be associated with a higher risk of violence and violent crimes.(8, 9)

One built environmental feature that may shape violence risk is walkability, a term describing how physical environmental features influence the likelihood of walking being used as a mode of transport. The Environmental Protection Agency's Walkability Index, a widely used metric for quantifying walkability, incorporates measures such as the proximity to public transit stops and the diversity of land uses.(10) Walkability has been associated with several positive health outcomes including increased physical activity, lower rates of obesity, and improved mental health. Also, people with chronic illnesses have been shown to have better health in areas with high street connectivity (11). Walkable neighborhoods foster social interactions, which improve trust and social cohesion (12)

Aside from a recent study in Youngstown, OH,(13) most research on built environment and youth violence has been undertaken in large urban centers.(5-9) Little is known about whether this work translates into mid-sized cities. Importantly, mid-sized cities tend to have less dense urban centers and differential distribution of residential and commercial spaces, including substance retailers,(13) meaning where people spend time and how they move between places may differ fundamentally between dense urban centers and mid-sized cities. Instead of extrapolating findings from large cities, it is imperative to examine these associations across a range of city contexts.

In particular, features like neighborhood walkability, transit infrastructure, access to green space, and substance retailers may play a role in violence risk. This study examined associations between the built environment and youth violence perpetration among Pittsburgh male youth to understand how neighborhood contexts may be leveraged to reduce youth violence in mid-sized cities.

Methods

Participants

To assess associations between built environmental features and violence perpetration, we utilized baseline data from a recently-completed cluster-randomized study that enrolled 866 male adolescents, ages 13-19 years, through youth-serving community agencies in 20 lower-resource neighborhoods in Pittsburgh, PA. Participants completed anonymous, baseline

surveys in-person on tablets (iPad Air; Apple) about violence perpetration, school enrollment and demographic characteristics. Baseline data were collected between August 2015 and June 2017 and analyzed June 2018 to March 2019. Further details of the study protocol have been previously described in detail.(14)

Measures

Built Environment—The study was designed such that youth attended study programming near their place of residence; therefore, the study sites were used to define individuals' exposure. To ascribe exposure at each of the study sites, we collected temporally-aligned data on six environmental variables retrieved from the following sources: U.S. Environmental Protection Agency (street intersection density and walkability (National Walkability Index scores); census block group), the Western Pennsylvania Regional Data Center (tobacco outlets and bike lanes; point and line location, respectively), the Pennsylvania Liquor Control Board (alcohol outlets; point location), and the U.S. Geological Survey (green space quality (median normalized difference vegetation index (NDVI) in 0.25-mile radius); satellite raster image). These geographic data were then converted to raster map layers using kernel density (point-based data) and inverse distance weighting (polygon-based data) calculations, using the default bandwidths in ArcGIS (ArcMap 10.6). Study site locations were overlaid on each raster layer to calculate exposure. Kernel density and inverse distance weighting measures are continuous and boundary-free, which assists in avoiding inappropriate aggregation effects.(15)

Violence perpetration—Violence perpetration was measured on baseline surveys by three validated Youth Risk Behavior Surveillance System items: physical fighting, threatening someone with a weapon, and injuring someone with a weapon in the past nine months. Each item was dichotomized as any/none for analyses.(16)

Statistical analysis

Three sets of multilevel logistic regression models separately examined associations between each of the six neighborhood built environmental features and the three violence perpetration outcomes, accounting for clustering of participants at the neighborhood level. The first model was unadjusted, the second adjusted for individual-level confounders (age, race, ethnicity, caregiver education, school enrollment, and intervention group) and the third adjusted for the individual-level confounders in model 2 along with neighborhood-level factors (median household income, unemployment, and population density from the American Community Survey) (17). Likelihood ratio tests comparing models that additionally accounted for clustering of sites (n=1-3) within neighborhoods were not significant, and thus final models only accounted for clustering at the neighborhood level. Statistical analyses were carried out using Stata SE 14 (StataCorp, TX).

Results

Mean participant age was 15.5 years. Seventy-eight percent of participants were African American, 4% Caucasian, and 6% Hispanic (Table 1). In the past 9 months, 66.4% reported being in a fight, 28.6% reported threatening someone with a weapon, and 14.7% reported

injuring someone with a weapon.(18) Walkability across the neighborhoods ranged from 11.9 to 18.6 (ideal walkability=20; Figure 1). Better neighborhood walkability was associated with significantly lower odds of fighting ($AOR_{individual\text{-}level\text{-}adjustment}$ 0.84, 95%CI:0.73-0.96; $AOR_{individual\text{-}and\text{-}neighborhood\text{-}level\text{-}adjustment}$ 0.86, 95%CI:0.76-0.99; Table 2). Bike lanes were associated with lower odds of fighting after individual-level adjustment (AOR 0.90, 95%CI:0.81-1.00), but results were not statistically significant after adjustment for neighborhood-level factors. The density of substance outlet retailers was inversely associated with violence perpetration across the adjusted models (AORs 0.89-0.96). Green space quality was associated with slightly increased odds of threatening ($AOR_{individual\text{-}and\text{-}neighborhood\text{-}level\text{-}adjustment}$ 1.002, 95%CI:1.0001-1.003) and injuring ($AOR_{individual\text{-}and\text{-}neighborhood\text{-}level\text{-}adjustment}$ 1.004, 95%CI1.001-1.006) someone with a weapon. There were no significant associations between street intersection density and violence perpetration.

Conclusion

Several built environmental features were significantly associated with violence perpetration, after accounting for both individual and neighborhood-level factors. In particular, walkability was associated with significantly lower odds of reporting fighting. These findings are consistent with research from large urban centers showing inverse associations between built environmental features that promote walkability and violence.(7, 11)

Higher levels of walkability encourage people to spend time outside interacting with their neighbors. By facilitating social interactions, walkability may increase neighborhood social cohesion,(12) and, in turn, mediate risk of violence within neighborhoods. Higher levels of social cohesion among neighbors have been shown to be associated with lower rates of violence.(19) The current findings extend emerging studies from large urban centers, and suggest that walkable neighborhoods in mid-sized cities may also serve as a protective factor in youth violence.

Surprisingly, alcohol and tobacco outlets were associated with slightly lower odds of reporting fighting, differing from extensive evidence showing a positive relationship between substance outlets and violent crime.(8, 9) One possible explanation for these findings is that these retailers might be serving as proxies for more mixed-use commercial-residential spaces, which have been linked to lower levels of violence.(20) This study also focused on self-reported violence perpetration; associations between the built environment and adolescent violence perpetration may differ from associations with more severe violent crimes.

One explanation for null findings for several of the street infrastructure features examined is that there may not be significant relationships between these features and violence perpetration in mid-sized cities. The null associations may also be a function of the study design. Many of the study sites used to define participants' exposure were in highly-accessible locations in lower-resource neighborhoods, which may have led to less variation in features across the sites. Without variation in exposures it is much less likely that an effect

would be detected, resulting in the model not detecting a correlation between these features and violence perpetration outcomes.

This study has several limitations. As a cross-sectional survey, observed associations cannot be inferred as causal. Violence perpetration measures used self-report, which can be subject to reporting bias. There is potential for unmeasured confounding. Accurate measures across the county for some potential confounders are not available, and, thus, not included in our analysis. Some of the spatial data were only available at larger geographic scales, which may make it more difficult to decipher nuances in environmental contexts between adjacent areas. To protect participant confidentiality, participants' home locations were not collected; instead the sites where participants attended programming were used as proxies. Important strengths include a large sample of male youth, multiple measures of violence perpetration, detailed assessment of multiple environmental features, and spatial analytic methods that maximize utility of the available data.

These findings contribute to the growing body of literature demonstrating the positive correlations between neighborhood walkability and improved overall health.(11) In this study, more walkable neighborhoods were associated with lower odds of violence perpetration. Walkable streets can serve as an important public health approach to reduce violence, and promote the wellbeing of the general population. Future research should incorporate granular geospatial data and objective measures of violence across multiple mid-sized cities to identify promising avenues for place-based interventions in these contexts.

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Key Messages:

What is already known on this subject:

- Male youth in lower-resource neighborhoods are disproportionately burdened by violence.
- Environmental contexts in large, urban centers may influence rates of violence and crime.

What this study adds:

- Extends previous work from large, urban centers and highlights the importance of examining associations between built environmental features and youth violence across a range of city contexts.
- Increased walkability may serve as a protective factor for youth violence in the context of mid-size cities.

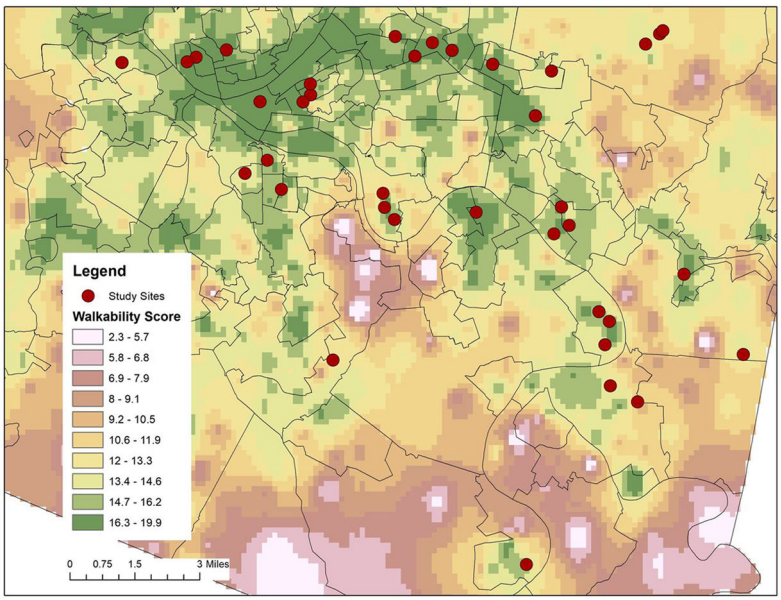

Figure 1.
Locations of programme sites overlaid on National Walkability Index scores.

Table 1.

Participant and neighborhood characteristics

Participant Demographics	**Total (%) n = 866**
Age (years)	
13-14	280 (32.3)
15-16	338 (39.0)
17-19	246 (28.4)
Race	
Black/African-American	632 (77.5)
White	30 (3.7)
Other	125 (14.5)
Ethnicity	
Hispanic	53 (6.1)
Educational status	
Currently in school	734 (84.8)
Not in school	
Completed high school degree	28 (3.2)
Did not complete high school degree	43 (5.0)
Highest educational level of parents/guardians	
Did not complete high school	378 (43.6)
Completed high school or received GED	149 (17.2)
College degree or higher	208 (24.0)
Violence perpetration	
Fighting	545 (66.4)
Threatening someone with a weapon	236 (28.6)
Injuring someone with a weapon	121 (14.7)
Neighborhood characteristics	**Mean (SD)**
Median household income	$35,950 (26,112)
Unemployment	8.35% (4.7)
Population density (people per square mile)	6,110 (3,098)
Neighborhood physical features	**Mean (SD)**
Walkability (National Walkability Index score)	14.9 (0.07)
Street intersection density (intersections per square mile)	180.7 (3.2)
Bike lane density (bike lanes per square mile)	2.5 (0.09)
Alcohol outlet density (alcohol outlets per square mile)	10.3 (0.52)
Tobacco outlet density (tobacco outlets per square mile)	6.5 (0.15)

Participant Demographics	**Total (%) n = 866**
Median NDVI score in 0.25-mile radius	327.5 (4.0)

Table 2.

Odds ratios for associations between neighborhood physical features and violence perpetration.

	Model 1: Unadjusted[a]			Model 2: Adjusted for individual-level factors[b]			Model 3: Adjusted for individual and neighborhood-level factors[c]		
	Fighting	Threatening someone with a weapon	Injuring someone with a weapon	Fighting	Threatening someone with a weapon	Injuring someone with a weapon	Fighting	Threatening someone with a weapon	Injuring someone with a weapon
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Walkability	0.88 (0.77, 1.00)	0.95 (0.86, 1.05)	**0.87** (0.78, 0.97)	**0.84** (0.73, 0.96)	0.96 (0.87, 1.05)	0.93 (0.81, 1.08)	**0.86** (0.76, 0.99)	0.95 (0.85, 1.01)	0.91 (0.79, 1.06)
Street intersection density	1.00 (0.997, 1.00)	0.999 (0.997, 1.00)	0.999 (0.996, 1.00)	0.998 (0.996, 1.01)	0.999 (0.997, 1.001)	0.9998 (0.997, 1.002)	0.999 (0.996, 1.00)	0.999 (0.997, 1.00)	0.999 (0.997, 1.00)
Bike lanes	0.92 (0.82, 1.01)	0.95 (0.88, 1.02)	0.95 (0.86, 1.04)	**0.90** (0.81, 1.00)	0.96 (0.89, 1.03)	1.00 (0.90, 1.12)	0.94 (0.84, 1.06)	0.93 (0.85, 1.03)	0.996 (0.88, 1.13)
Alcohol	**0.98** (0.96, 0.99)	0.99 (0.98, 1.00)	**0.98** (0.96, 1.00)	**0.98** (0.96, 0.99)	0.99 (0.98, 1.01)	0.99 (0.97, 1.01)	**0.96** (0.93, 0.98)	**0.96** (0.94, 0.99)	**0.96** (0.93, 0.995)
Tobacco	**0.93** (0.88, 0.97)	**0.95** (0.91, 0.98)	**0.93** (0.88, 0.98)	**0.91** (0.87, 0.96)	**0.96** (0.92, 0.995)	0.95 (0.89, 1.01)	**0.90** (0.85, 0.96)	**0.89** (0.84, 0.95)	**0.90** (0.83, 0.98)
Green space	1.00 (0.999, 1.00)	1.001 (0.9998, 1.002)	**1.003** (1.001, 1.005)	1.002 (0.9996, 1.004)	1.001 (0.9998, 1.003)	**1.003** (1.001, 1.005)	1.00 (0.999, 1.00)	**1.002** (1.0001, 1.003)	**1.004** (1.001, 1.006)

Bolded AORs indicate a p-value < 0.05

[a] Models account for neighborhood-level clustering

[b] Adjusted for age, race, ethnicity, caregiver education, school enrollment, and intervention group

[c] Adjusted for individual and neighborhood-level factors (model 2 individual-level factors plus neighborhood median household income, unemployment, and population density)