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Route choices and adolescent-adult connections in mitigating exposure to environmental risk factors during daily activities

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Abstract

While adolescent-adult connections have been shown to be protective against violence perpetration and victimization, mechanisms through which these connections confer protection from violence are poorly understood. We assessed whether adolescent-adult connections protected youth in lower resource urban neighborhoods from exposure to environmental risk factors for violence during daily activities. We overlaid on the city landscape minute-by-minute activity paths from 274 randomly sampled predominantly African American male youth, ages 10–24, enrolled in a population-based study of daily activities in Philadelphia, PA, to calculate environmental exposures and to compare exposures along actual versus shortest potential travel routes. Adolescent-adult connections were defined using brief survey questions and detailed family genograms. Analyses demonstrated youths' selected travel routes resulted in significantly lower exposure to several types of crime, including vandalism, narcotics arrests, and disorderly conduct, than would have occurred on shortest potential routes. On average, youth with adolescent-adult connections spent less time outdoors than youth without connections, though these differences did not reach statistical significance (p=0.06). There were no significant differences in environmental risk factors encountered by youth with versus without adolescent-adult connections. Future mixed method research combining qualitative and GIS approaches should investigate which factors shape travel decisions during daily activities to guide multi-modal violence prevention interventions.

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youth violence; adolescent-adult connection; travel path; spatial analysis; environmental exposures

Youth violence is common and leads to significant morbidity and mortality. Homicide is the third leading cause of death among U.S. adolescents and more than 600,000 youth seek care in U.S. emergency departments annually for assault-related injury (Centers for Disease Control and Prevention [CDC], National Center for Injury Prevention and Control, 2019). In 2017, 24% of high school-aged respondents in the United States reported being in a physical fight in the past year and 16% carried a weapon during the preceding month (Kann et al., 2018). Rates of violence exposure are even higher among minority youth living in low-resource urban environments, with 50% to 97% reporting witnessing violence and 50% to 70% directly experiencing violence victimization (Hardaway, McLoyd, & Wood, 2012; McDonald, Deatrick, Kassam-Adams, & Richmond, 2011; Zimmerman & Messner, 2013).

Youth violence in context

Tackling complex public health problems such as youth violence requires exploring the interplay between risk and protective factors at multiple levels of influence beyond the individual, including families, communities, and environmental contexts (David-Ferdon & Simon, 2014; Frieden, 2010). Adolescent-adult connections with parents, extended family, and adult mentors are associated with lower levels of violence involvement, including witnessing and directly experiencing violence (Culyba et al., 2016b; DuBois & Silverthorn, 2005; Hall et al., 2012b; Loeber & Farrington, 2012; Losel & Farrington, 2012; Resnick, et al., 1997). Among youth exposed to neighborhood violence, adolescent-adult connections may reduce the risk of future violence perpetration (Brookmeyer, Henrich, & Schwab-Stone, 2005; Gorman-Smith, Henry, & Tolan, 2004; Jain & Cohen, 2013). The Centers for Disease Control and Prevention identifies strengthening adolescent-adult connections as a promising strategy for youth violence prevention (David-Ferdon & Simon, 2014).

Environmental contextual factors also play an important role in shaping violence risk. Studies have demonstrated that environmental factors like crime rates, alcohol outlets, gun distributors, and vacant lots increased risk for assault injury (Branas, Elliott, Richmond, Culhane, & Wiebe, 2009; Branas, Rubin, & Guo, 2013; Wiebe et al., 2009; Wiebe et al., 2016). These environmental risk factors can influence social interactions and shape people's willingness to monitor neighborhoods, which, in turn, can impact neighborhood crime and violence (Aiyer, Zimmerman, Morrel-Samuels, & Reischl, 2014; Kuo & Sullivan, 2001). Accurately measuring an individual's environmental exposure is crucial to understanding the risks faced by youth (Basta, Richmond, & Wiebe, 2010; Buliung, Larsen, Faulkner, & Stone, 2013; Cummins, Curtis, Diez-Roux, & Macintyre, 2007; Flowerdew, Manley, & Sabel, 2008; Geronimus, 2006). Exposure levels at specific geographic point locations and moments in time may more accurately predict risks (Branas et al., 2009; Wiebe, Blackstone, Mollen, Culyba, & Fein, 2011; Wiebe et al., 2016), yet few studies use methods that capture this granular data (Hall, Simon, Lee, & Mercy, 2012a).

Together, these studies highlight the need to take the dynamic interplay between youth, their adult supports, and environmental contexts into account when studying violence risk. The current study uses detailed GIS activity path data and multiple measures of adolescent-adult connections to examine whether adolescent-adult connections may influence the extent to which youth are exposed to environmental risk factors during their daily activities.

Environmental contexts and route choices

Where youth spend time and how they choose to travel between places are important factors in determining the environmental contexts to which youth are exposed. A body of research predominantly among adult populations suggests that environmental features such as distance, aesthetics, safety, functionality, and destinations contribute to walking patterns (Saelens & Handy, 2008; Sugiyama, Neuhaus, Cole, Giles-Corti, & Owen, 2012). For instance, among a sample of 321 pedestrians in New York and Hong Kong, Guo and Loo (2013) found that participants' chosen routes aligned with features of streetscapes and infrastructure. Borst, Miedema, de Vries, Graham, and van Dongen (2008) found that among older adults, features such as businesses, green space, and transit contributed to the route attractiveness, while the presence of litter made routes less appealing. Using walking interviews, Van Cauwenberg et al. (2012) identified availability of retailers, aesthetics, sidewalk conditions, social interaction, and safety from crime as key elements related to walking routes. Research among adults in urban Swedish neighborhoods demonstrated that participants selected routes with high building density and better perceived social qualities (e.g., discretion) (Ferreira, Johansson, Sternudd, & Fornara, 2016).

Research specifically examining environmental contexts and route choices among youth is limited and has tended to focus on active transit to and from school, inclusive of both walking and cycling routes. In a study among adolescents in three U.S. cities, measuring active transport via surveys and accelerometers, and assessing environmental contexts with the Microscale Audit of Pedestrian Streetscapes (MAPS) tool, Cain et al. (2014) found that destinations, non-residential land use, and streetscape characteristics were directly related to walking or biking for transport. Linking data from a subsample of these participants living in close proximity to their schools with GIS data about their home and school environments, Carlson et al. (2014) found that residential density, perceived street connectivity, and perceived pedestrian safety were associated with active transit to school. Dessing et al. (2016) used GPS-based data to assess features along actual versus shortest routes among 8-to-12-year-olds and found that youth avoided busy roads. A recent study using GPS-based cycling path data among 12-to-16-year-olds in Belgium also found that youth selected routes that were less busy and tended to avoid arterial roads (Verhoeven et al., 2018).

Perceived safety and adolescent-adult connections

Perceived safety may be a particularly salient factor in walking patterns, especially among youth in urban neighborhoods (Panter, Jones, & van Sluijs, 2008). Through a series of studies among college students in an inner-city campus, researchers found that youth actively selected routes to minimize safety concerns, and that these safety concerns were closely aligned with features in the participant's immediate surroundings that influence

prospect, refuge, and escape (Fisher & Nasar, 1992; Nasar & Fisher, 1993; Nasar, Fisher, & Grannis, 1993). In urban environments, youth perceptions of safety have been shown to vary substantially during travel to school and have been linked to modes of transit (Wiebe et al., 2013). Qualitative research in a sample of Philadelphia youth residing in dangerous neighborhoods highlighted adolescents' hypervigilance to environmental features in their immediate surroundings and their keen focus on strategies to promote safety during daily activities (Teitelman et al., 2010).

Research examining the role of adolescent-adult connections and perceived safety on route choice is limited, and centers almost exclusively on parental relationships. Most studies either focus entirely on perceived traffic-based safety, or examine perceptions of traffic and crime jointly, making it challenging to disentangle the effects of perceived violence risk. Among a sample of youth in Norfolk, U.K., parental attitudes and safety concerns (defined broadly) were predictors of active commuting (Panter, Jones, van Sluijs, & Griffin, 2010). A recent study by Wilson, Clark, and Gilliland (2018) found that parental perceptions of safety had a greater influence on active travel than youths' perceptions. Among 9-to-13-year-olds in London, Canada, Loebach and Gilliland (2014) found that participants with lower youth and parent perceived safety risk traveled farther from home in the course of their daily activities. In some violent neighborhoods adults limited the time youth could spend outside, thereby limiting travel away from home (CDC, 2002). Youth also cited caring and engaged adults as important in teaching them how to safely navigate dangerous neighborhoods (Teitelman et al., 2010). These studies suggest that parental relationships, and both youths' and parents' perceived safety, may broadly be playing a role in travel patterns among youth.

However, few prior studies of adolescent travel patterns incorporate objective measures of travel paths or contextual risk factors for violence (Wiebe et al., 2013). Work by Guo and Loo (2013) demonstrated that participants' expressed preferences for factors such as safety, familiarity, and distance did not necessarily correspond to objectively measured features along the paths that pedestrians actually selected. Brown, Perkins, and Brown (2004) also noted that while physical incivilities such as graffiti and dilapidated houses can predict future crime, residents' perceptions of these environmental features were not well correlated with crime. One recent study by Rodríguez et al. (2015) used objective environmental contextual data derived by field audits to assess route choice aesthetics, destinations, functionality, and safety among female adolescents in San Diego, CA, and Minneapolis, MN. They compared GPS-based travel paths to alternative paths, and found that route length, traffic safety, green space, and abandoned buildings were all positively associated with route choice. While the study did include measures of contextual risk factors associated with violence (e.g., abandoned buildings), these were considered aesthetic features and the safety assessment was limited to pedestrian infrastructure (e.g., crosswalks). Taken together, these studies highlight the complexity inherent in examining how environmental contexts and route choices influence adolescent violence risk, and the need for additional research that links survey, GIS, and environmental contextual data.

The present study

The present study builds upon this prior work by using objective GIS data to advance our understanding of how youth in lower resource urban neighborhoods navigate sometimes dangerous physical environments in a manner that may confer safety. Using minute-by-minute GIS activity path data and multiple measures of adolescent-adult connections, this is the first study to examine whether adolescent-adult connections may influence the extent to which youth are exposed to environmental risk factors during their daily activities. We postulate that having adult connections may change how youth navigate their neighborhoods, altering their exposure to environmental risk factors for violence and impacting their risk of assault.

We examined this overarching hypothesis using two GIS analytic approaches. First, we examined whether youth with versus without adult connections were differentially exposed to environmental risk factors for violence over the course of an entire day of activities. In keeping with prior research which suggests a protective effect of adolescent-adult connections (DuBois & Silverthorn, 2005; Resnick et al., 1997), and that adults may limit the amount of time youth spend outside (CDC, 2002), we hypothesized that youth who identified positive adult connections would be exposed to lower levels of environmental risk factors in the course of their daily activities. Second, we examined how youth traveled between activities in order to determine whether youth with adult connections selected routes that minimized their exposure to environmental risk factors for violence. Informed by prior qualitative research among urban Philadelphia youth (Teitelman et al., 2010), we hypothesized that youth with positive adult connections would be more likely to select routes that minimized exposure to environmental risk factors. Advancing our understanding of the potential interplay between adolescent-adult connections, route choices, and environmental risk factors for violence can identify targets for multi-level interventions designed to protect youth.

Method

Participants

We utilized data from 274 control participants in the Space-Time Adolescent Risk Study (STARS), a population-based case control study of daily activities and assault. The parent study recruited case subjects ages 10 to 24 between 2007 and 2011 from two adjacent Level I trauma centers in Philadelphia, PA. Controls were recruited using random digit dialing of landlines from the 12 zip codes comprising the homes of case subjects and matched to cases on race and age group (10–14, 15–17, 18–24 years) (Hartge et al., 1984; Perneger, Myers, Klag, & Whelton, 1993; Waksberg, 1978). The response rate for controls (52.8%) was similar to other concurrently conducted random-sample surveys and suggested enrollment of a comparably representative sample (Baruch & Holtom, 2008; Groves, 2006; American Association for Public Opinion Research, n.d.). Most cases and matched controls were African American, and they tended to reside in lower resource neighborhoods in Philadelphia, which is reflective of the disproportionate burden of violent injury born by minority male youth in urban neighborhoods (CDC, 2019). The study was approved by the Institutional Review Boards at the University of Pennsylvania and The Children’s Hospital

of Philadelphia. Informed consent (parental permission with participant assent for youth <18 years of age; participant consent for youth ≥18 years of age) was obtained from all individual participants included in the study.

Procedures

All subjects underwent a structured in-person interview led by a study coordinator, which was conducted in a research office or their home, based on participant preference. Participant interviews covered a range of topics including violence exposure, school performance, adult and peer connections, and substance use. Then, participants completed a detailed activity path mapping activity using a customized version of ArcEngine software (Esri, Inc., Redlands, CA). Control participants were asked to sequentially report their daily activities by location and time for a recent day (within 3 days of the interview) designated randomly. As each subject provided a minute-by-minute description of their entire day from when they woke up to when they went to sleep, the interviewer used a stylus to draw points on the interactive map to recreate the participants' path. Each path point was marked with a geocode (latitude/longitude coordinates). Thus, the interviewer created a minute-by-minute record of how, when, where and with whom the subject spent time over the course of an entire day. Further details for the geographic information system (GIS) data collection have previously been described (Basta et al., 2010; Wiebe et al., 2013; Wiebe et al., 2016).

Measures

Adolescent-adult connections.—Adolescent-adult connections were measured using two approaches. First, *positive adult connection* was defined by answering two questions affirmatively during the structured in-person interview: "there are adults in my life that I look up to" and "there are adults in my life that I can go to that help me handle tough situations." In keeping with prior research, these questions were chosen to broadly and succinctly capture connections both within the family and with other supportive adults (DuBois & Silverthorn, 2005; Resnick et al., 1997). This measure has been found to be significantly inversely associated with self-reported violence involvement and witnessing violence among the study participants (Culyba et al., 2016a).

Second, we more specifically measured supportive connections within family contexts. Participants created detailed family genograms to characterize relationships with family members who they felt played an important role in their lives. To accomplish this, youth delineated salient adult familial relationships, which the interviewer used to generate an individualized genogram template. Next, using both pre-specified (e.g., physical fighting, verbal fighting, not good, supportive) and participant-generated (e.g., "talks to me about a lot of stuff," "shaky sometimes") descriptors, participants characterized the relationship quality for each familial connection. Based on the constellation of descriptors reported by youth, relationships were subsequently divided into two categories: supportive and unsupportive. *Supportive adult familial connection* and *supportive parental connection* were defined by the presence of ≥1 supportive adult family member and ≥1 supportive parent, respectively, in family genograms.

Environmental exposures.—We collected annual data on the precise point locations of eight environmental variables of interest across Philadelphia between 2007 and 2011. Data sources included the University of Pennsylvania Cartographic Modeling Lab (vacant properties), the Philadelphia Police Department (vandalism, disorderly conduct, public drunkenness, narcotics arrests), the City of Philadelphia (recreation department facilities), the Pennsylvania Liquor Board (alcohol outlets), and the Mural Arts Program (murals) (Cartographic Modeling Lab, n.d.; Mural Arts Philadelphia, n.d.). We used the Public Health Management Corporation (PHMC)'s 2010 Southeastern Pennsylvania Household Survey to determine the proportion of residents who had experienced violent victimization in the past year (violence victimization) and the proportion who reported firearms in or around their home (guns in/around home) in each census tract (Public Health Management Corporation, 2010).

Home address-based environmental exposure determination.—Separately for each study year, we geographically referenced each environmental variable with latitude and longitude coordinates, and converted these to raster map layers using kernel density (CML, Philadelphia Police Department, City of Philadelphia, Pennsylvania Liquor Board, Mural Arts) and inverse distance weighting (PHMC) calculations. Using smooth surface layers more accurately ascribes environmental exposures to participant's unique locations (Geronimus, 2006; Holt, Steel, & Tranmer, 1996; Longley, Goodchild, Maguire, & Rhind, 2005; Tomlin, 1990). We overlaid the locations of participants' home addresses on the raster layers to define exposure.

Activity path-based environmental exposure determination.—Participants' detailed minute-by-minute activity paths were overlaid on the same environmental raster map layers of the Philadelphia landscape. Using ArcGIS 10.3.1, we assigned environmental exposures based on the latitude and longitude of each activity path point and then calculated mean exposures over participants' entire activity path to each environmental variable of interest.

Trip path-based environmental exposure determination.—We used a unique approach to explore how youth chose to travel between their daily activities by dividing participants' activity paths into series of origins and destinations (e.g., activity path from home to school, path from school to work) (Culyba, Guo, Branas, Miller, & Wiebe, 2018). A single trip was defined by an origin, the intervening travel points, and a destination. We limited the trip path analyses to trips using ≥90% self-powered modes of transit (on foot, bicycle) because adolescents have the most personal agency in selecting travel paths under these circumstances. To calculate shortest potential trip paths, we used the ArcGIS 10.3.1 Network Analyst feature with the NAVTEQ StreetMap Premium for ArcGIS (2012 map layer) to calculate the shortest potential walking route between each origin and destination. We calculated measures of exposures to environmental features along the actual trip paths and the shortest potential trip paths using two distance buffers consistent with those employed in prior research: 1) 60-ft buffers to reflect exposure to environmental features along the street that participants traversed, and 2) 660-ft buffers to capture exposures within a city block of each trip path (Han, Branas, & MacDonald, 2016; Kondo, Keene, Hohl,

MacDonald, & Branas, 2015). We calculated exposure density (exposure per 1,000 feet traversed) along each actual trip path and shortest potential trip path.

Statistical analysis

The objectives of the proposed analysis were twofold: 1) to examine whether youth with adult connections were differentially exposed to environmental risk factors during their daily activities, and 2) to estimate whether youth with adult connections selected routes that minimized their exposure to environmental risk factors. To characterize the study sample, we calculated descriptive statistics including mean, standard deviation, median, and interquartile range.

For the first objective, we used ordinary least squares (OLS) regression to test for differences in environmental exposures at participants' home addresses between participants with and without adolescent-adult connections, defined by: 1) positive adult connection, 2) supportive adult familial connection, and 3) supportive parental connection. We then examined the amount of time that youth spent in eight location types (e.g., inside home, outdoors) across their daily activities. We used t-tests to compare the percentage of time that youth with and without adolescent-adult connections spent outdoors. We next used OLS regression to test for differences in mean exposure accrued over the entire path of daily activities between subjects with and without each of these measures of adolescent-adult connection. Fully adjusted models accounted for individual factors (age, school enrollment, currently working, history of juvenile probation, prior violence involvement) and contextual factors (mode of transit, proportion of path traversed after sundown, presence of precipitation, alcohol use, presence of companions) along activity paths. We additionally included environmental constructs from factor analysis performed with the entire case-control participant sample (connectedness among neighbors, neighborhood income, neighborhood racial/ethnic composition, fire and police stations) to efficiently account for potential confounding (Wiebe et al., 2016). Models tested for presence of effect modification by age, which was not significant at the $p < .1$ level, and was removed from final models.

For the second objective, we used GIS analytics to compare exposures along actual trip paths to shortest potential trip paths (Culyba et al., 2018). We calculated, within each subject, for each set of origin and destination points, the difference in exposure density between the shortest potential trip path and the actual trip path: (difference [density]=shortest potential trip path exposure per 1,000 feet traversed – actual trip path exposure per 1,000 feet traversed). The primary outcome was the mean difference in exposure density across each participant's trips. We used OLS regression to evaluate whether the observed differences in exposure between shortest potential routes and actual routes differed based on whether subjects reported positive adult connection, supportive adult familial connection, and supportive parental connection.

Results

Characteristics of participants

The study included 274 adolescent male participants who completed both structured in-person interviews and activity path data collection. Mean participant age was 17.9 years and 98% were African American (Table 1). Adolescent-adult connections were common with 86% reporting positive adult connection, 79% reporting supportive adult familial connection, and 75% reporting supportive parental connection. Almost all youth had been in a fistfight (92%) and 13% required medical attention following a fight. One-third (39%) had carried a weapon and one-fifth (18%) had been on probation. Participants reported high levels of witnessing neighborhood violence, including hearing gunshots (88%) and seeing someone beaten up (78%). Three-fourths (74%) endorsed changing their travel route based on safety concerns, with 18% doing so daily and an additional 20% doing so weekly.

Adult connections and exposure to environmental risk factors at home address

There was geographic overlap in the home address locations of participants with and without adult connections, except for the few participants residing in Northeast Philadelphia, who more commonly had adult connections (figure available upon request). We identified a statistically significant association between the presence of positive adult connection and lower exposure to disorderly conduct at home address locations (Table 2). We did not identify any significant associations between positive adult connection and the other environmental exposures at participants' home addresses, including alcohol outlets, vacant properties, vandalism, violence victimizations, firearms in/around homes, narcotics arrests, or recreational centers. We found no significant associations between supportive adult familial connection or supportive parental connection and any of the environmental risk factors at home address locations.

Adult connections and location types where youth spent time

To characterize the location types where youth spent time, we graphed activity locations by hour of the day for participants with and without adolescent-adult connections (Figure 1). On average, youth with supportive adult familial connection spent less time outdoors (22.7% of daily activity) than youth who did not identify supportive familial connection (29.4%), but this difference was not statistically significant ($p=0.06$). The same pattern held true based on the presence of positive adult connection (23.8% vs. 26.9%; $p=0.46$) and the presence of supportive parental connection (23.2% vs. 26.6%; $p=0.36$).

Adult connections and exposure to environmental risk factors during daily activities

We graphically depicted participants' daily activity paths overlaid on environmental exposures of interest (figures available upon request). We found no significant associations between the presence of 1) positive adult connection, 2) supportive adult familial connection, or 3) supportive parental connection and exposure to any of the environmental risk factors for violence during the entire daily activity paths in unadjusted or fully adjusted models (results available upon request).

Comparing actual trip paths and shortest potential trip paths among all participants

Figure 2 depicts participants' actual trip paths and shortest potential trip paths overlaid on the location of vacant properties. Across the entire sample, we found significant differences between exposures along actual trip paths compared to what youth would have been exposed to had they chosen to travel along the shortest potential routes between origins and destinations (Table 3). On average, participants' actual trip paths traversed areas that had significantly less density of disorderly conduct than the shortest potential trip paths using both 60-ft and 660-ft buffers. Participants' actual trip paths traversed areas that had significantly less density of vandalism and narcotics arrests than the shortest potential trip paths using 60-ft and 660-ft buffers, respectively. The point estimates for the beta coefficients comparing exposure density along shortest potential trip paths to actual trip paths were all greater than 1, suggesting that exposure density might be lower along the actual trip paths, although the differences did not reach statistical significance across the other environmental risk factors.

Adult connections and exposure to environmental risk factors on actual trip paths versus shortest potential trip paths

We did not identify any significant associations between positive adult connection and differential exposure to environmental risk factors on actual trip paths versus shortest potential trip paths measuring exposure density with 60-ft or 660-ft buffers for any of the environmental risk factors of interest (Table 3). We also found no significant associations between supportive familial connection or supportive parental connection and differential exposure to the environmental risk factors on actual trip paths versus shortest potential trip paths (results available upon request).

Discussion

This is the first study to use GIS-generated activity path data to examine associations between adolescent-adult connections and exposure to environmental risk factors for violence in the context of daily activities among a sample of predominantly African American male youth. Environmental exposures measured at home address locations were very similar between those with and without all three forms of adolescent-adult connections. Although youth with adolescent-adult connections tended to spend less time outdoors, these differences did not reach statistical significance. Through detailed daily activity path analyses, we also found that exposures to environmental risk factors for violence in the context of daily activities were similar among youth with and without adolescent-adult connections.

We employed a novel methodologic use of GIS data to detect whether some participants selected travel routes that minimized their exposure to high concentrations of environmental risk factors for violence by comparing exposures along actual travel routes to shortest possible routes. Across the study sample, youth selected routes that resulted in exposure to lower levels of crime, including disorderly conduct, vandalism, and narcotics arrests. These findings provide preliminary support for the idea that youth may be selecting routes that result in lower exposure to environmental risk factors for violence, even though this often

entails taking a longer route. Importantly, none of the physical risk factors for violence (e.g., alcohol outlets) reached statistical significance. In contrast to the study by Rodriguez et al. (2015), which found that adolescent females chose routes with higher exposure to abandoned buildings, in the present study, we did not find a statistically significant association between travel routes and vacant properties. Our findings related to crime exposure across the study sample are in keeping with theories of prospect, refuge, and escape, and suggest that youth may select routes to minimize safety concerns (Fisher & Nasar, 1992; Nasar & Fisher, 1993; Nasar et al., 1993; Wang & Taylor, 2006). However, lack of statistically significant associations between physical risk factors for violence and route choice highlights the complex relationships between perceived safety, adolescent route choices, and environmental risk factors.

Contrary to our hypothesis, the present study did not find any statistically significant associations between adult connections and exposure to objective measures of environmental risk factors for violence. While research demonstrates that adolescent-adult connections reduce risk for exposure to violence (Brookmeyer, Fanti, & Henrich, 2006; Henrich, Brookmeyer, & Shahar, 2005; Resnick et al., 1997; Resnick, Ireland, & Borowsky, 2004), communication specifically about safety, rather than the general presence of adult connection, may be more influential in travel decision-making (Teitelman et al., 2010). Adult connections may be most critical in influencing route choices for younger youth who are just starting to navigate their neighborhoods, rather than remaining broadly influential across adolescence. It is possible that other social factors, such as peer networks, and other physical factors, such as lighting and walkability, are more salient to adolescents' travel decisions (Carver et al., 2005; Giles-Corti & Donovan, 2003; Panter et al., 2008).

Importantly, the present study included predominantly African American youth residing in lower resource urban neighborhoods. Youth reported high levels of lifetime violence exposure−-39% had carried a weapon, and 92% had been in a fight. Data from the 2011 Youth Risk Behavior Surveillance Survey among African American male youth in Philadelphia are generally consistent, with 19% having carried a weapon in the past 30 days and 47% reporting physical fighting in the past year (CDC, Youth Risk Behavior Surveillance System, 2011). Understanding the social and contextual factors that influence route choice among youth disproportionately impacted by violence is imperative in addressing these disparities.

Many of the quantitative studies on adolescent route choice have included predominantly Caucasian samples in smaller urban and more suburban settings (Dessing et al., 2016; Loebach & Gilliland, 2014; Panter et al., 2010; Rodríguez et al., 2015; Verhoeven et al., 2018; Wilson et al., 2018), and findings may not translate to lower resource urban contexts. Using self-reported travel diaries among a sample of 5-to-18-year-olds, Kerr, Frank, Sallis, and Chapman (2007) found that significant associations between urban form and walking for transit among Caucasian participants and those of affluent communities were attenuated among minority youth and those residing in lower income neighborhoods. Teitelman et al.'s (2010) qualitative work also speaks to the nuanced ways in which youth in urban neighborhoods assess contextual risk factors for violence. In that study, recreation centers were noted to be both safe spaces and places where conflict occurred; these safety/violence

dynamics varied across microenvironments (e.g., near the basketball court) and across time of day. While the present study adjusted for temporality and seasonality, observed null associations may be due to changes in microenvironments over time that were not fully captured through our GIS methods.

Future mixed methods research should explore the dynamic interplay between parent-adolescent communication, perceptions of safety, and decision-making in the context of daily activities. Combining qualitative interviews with GIS analytics may better identify opportunities for interventions that leverage adolescent-adult relationships to best promote safety.

Limitations and strengths

This study has several limitations. We measured adolescent-adult connections based on responses generated during a single in-person interview, which might fail to capture the dynamic nature of relationships, affect reliability and validity, and limit our ability to fully assess relationship characteristics and quality. The time-intensive nature of activity path data collection precluded ascertaining the content of adolescent-adult communication and activities youth and adults engaged in together. We are therefore unable to assess whether supportive adults specifically addressed how to safely navigate dangerous environments. While we did account for the presence of a companion in adjusted analyses, we did not specifically assess whether this companion was an adult. We are thus unable to study whether the specific physical presence of an adult companion altered route choice or exposure to environmental risk factors. The current analysis did not incorporate perceived safety, which may moderate associations between adolescent-adult connections and activity path choices. However, we did use several distinct measures of adolescent-adult connections including brief survey questions and detailed family genograms to provide a comprehensive approach to measuring connections.

Participant characteristics and the timing of data collection may impact generalizability and temporal external validity. While the sample included a broad age range (10-to-24-year-olds), the number of young participants was relatively small and precluded sub-analyses. However, we found no evidence of effect modification by age, suggesting that the null associations between connections and environmental exposures held true among younger adolescents as well as older youth in our sample. The data were collected from 2007 to 2011. Since that time, smartphone use has increased (Lenhart, 2015), which could impact how youth choose to navigate through their daily activities. While the study was not explicitly powered to separately examine route choices by calendar year, graphical representations and ad hoc analyses suggest that our findings were consistent across the study period, which lends credence to the temporal external validity. The study included a population-based sample of predominantly African American male youth residing in 12 lower resource zip codes in Philadelphia. Results may not be generalizable outside the study population or single location.

Our work focused predominantly on environmental risk factors for violence. Because data were collected as part of a larger case-control study examining environmental risk factors for assault injury, we specifically did not include measures of violent crime as they would be

highly correlated with the primary outcome of interest. However, prior research by our group and others suggests that crimes such as vandalism, disorderly conduct, public drunkenness, and narcotics arrests tend to follow a similar distribution in urban environments (Branas et al., 2009; Culyba et al., 2016c; Wiebe et al., 2011; Wiebe et al., 2016). At the time the study began (2007), geographic data on protective factors were much less readily available. Focusing on annually reported contemporaneous geographic data, there was limited ability to incorporate environmental protective factors in the current study.

The study has several important strengths. It uses detailed GIS data that capture the minute-by-minute activity paths of male youth in lower resource urban environments. Linking interview and activity path data to granular environmental exposure data, it is the first study to use objective measures of exposure to environmental risk factors for violence in assessing the impact that adolescent-adult connections may have on adolescent decisions for navigating daily activities. In doing so, it provides important insight into where youth spend time, and how the presence of adolescent-adult connections relate to exposure to environmental risks near home, across youths' daily activities, and along their chosen travel routes.

Conclusions

Violence impacts the life trajectories of far too many adolescents in the United States, with the highest incidence of violent victimization concentrated among African American youth in urban settings (Sumner et al., 2015). Effectively combating youth violence requires identifying risk and protective factors at multiple levels of influence including individual, family, community, and socio-structural factors.

In a population-based sample of male youth in an urban environment, we examined the role of route choices and adolescent-adult connections in exposure to environmental risk factors during the course of daily activities. We did not identify significant differences between youth with and without adolescent-adult connections in exposure to environmental risk factors for violence. We did note significant differences between exposures that youth encountered along their chosen travel routes in contrast to what they would have encountered along the shortest potential routes, suggesting youth may be going out of their way to avoid environmental risks.

Understanding the unique interplay between adolescents and environmental risk factors for violence may afford opportunities to tailor community revitalization interventions in ways that will best promote adolescent safety (Culyba et al., 2016c). The current study used granular GIS-based data and suggested youth may be selecting travel routes that confer safety. Future work should combine novel spatial methods that objectively measure environmental exposures with in-depth qualitative analysis to further explore nuances in adolescent route choice decision-making in neighborhoods with high levels of community violence. This mixed method approach may help to elucidate individual-, social-, and neighborhood-level factors that are most salient in youth decision-making and help inform multi-modal intervention strategies to protect youth.

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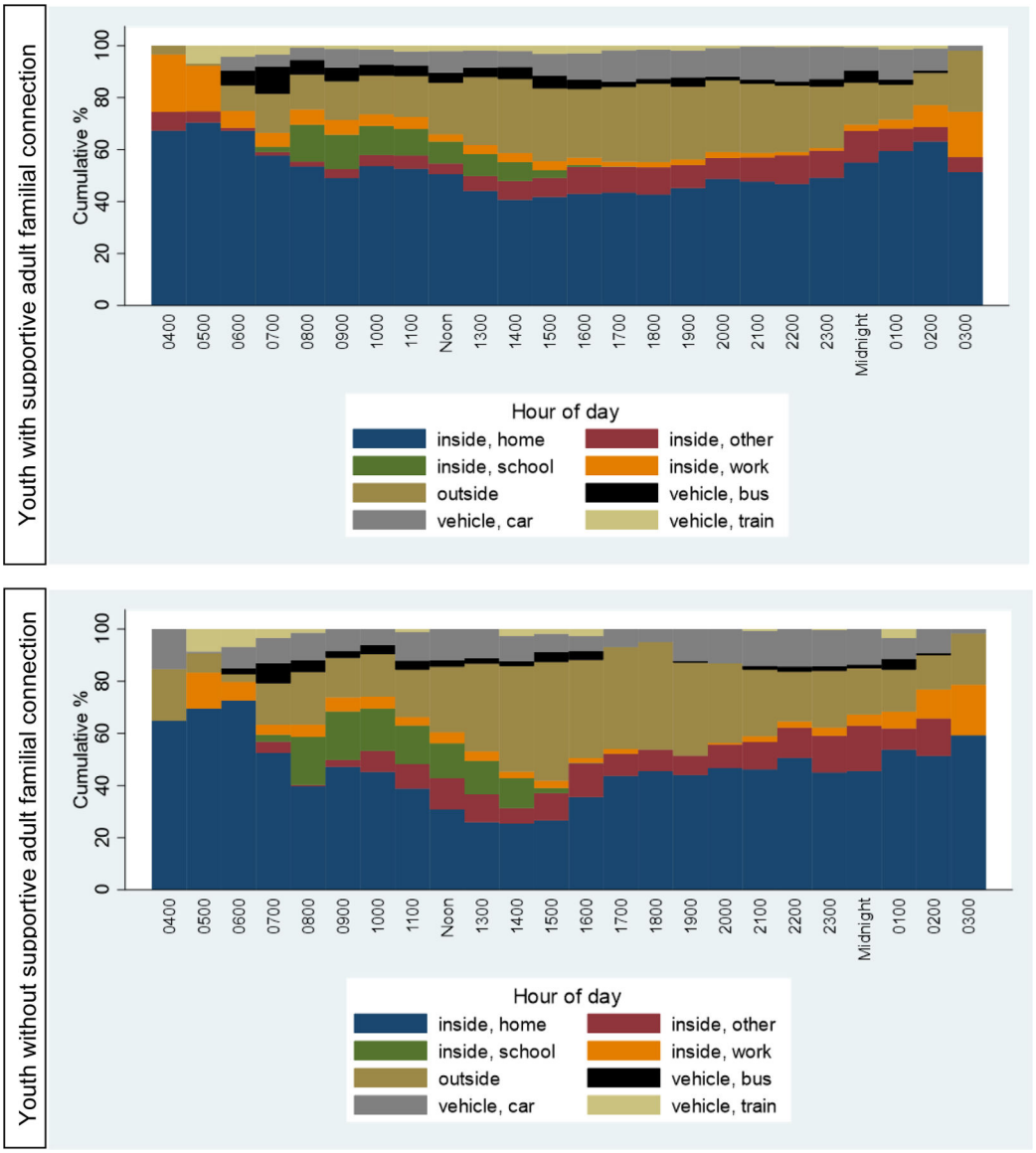

Figure 1:

Percentage of time during each hour of the day that participants spent in different location types

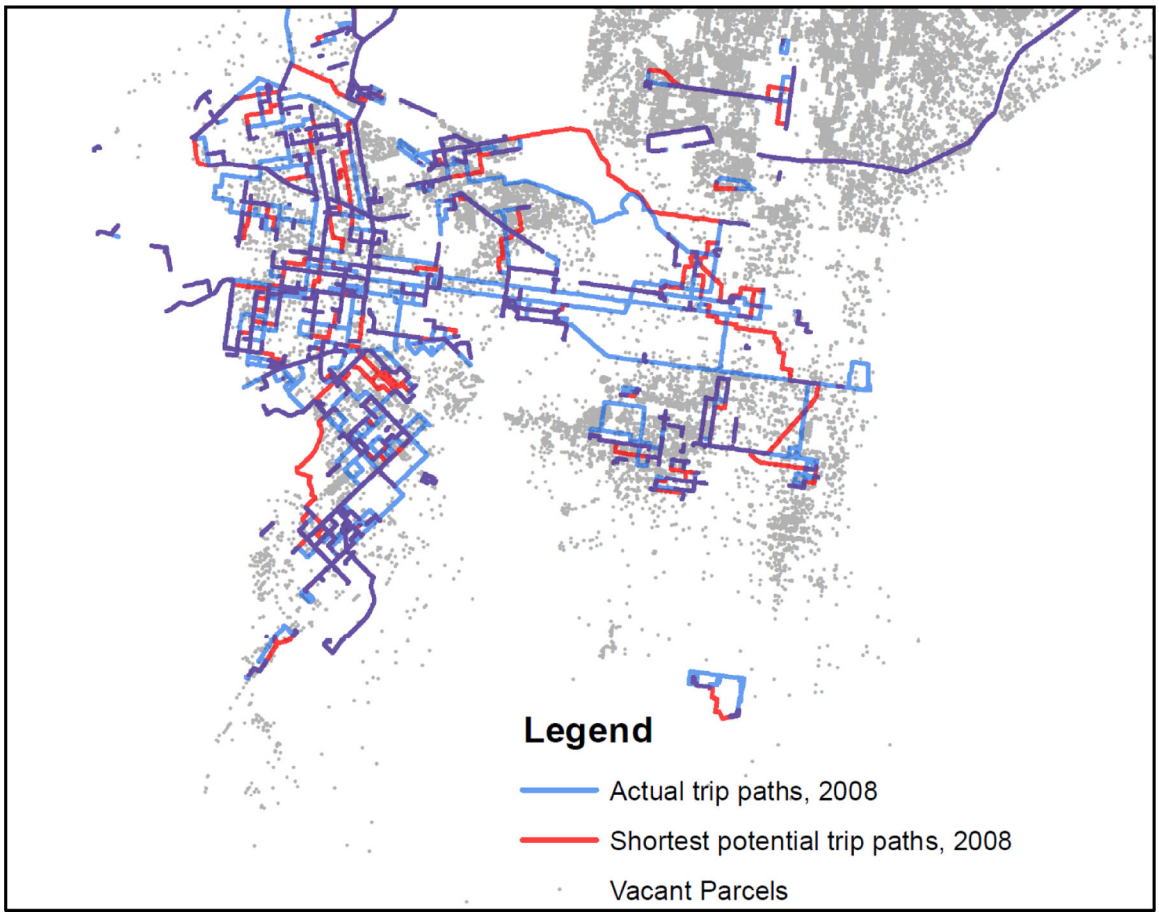

Figure 2:

Actual and shortest potential trip paths overlaid on the location of vacant properties in Philadelphia, PA, 2008

*dark blue lines represent areas of overlap between actual and shortest potential trip paths

Table 1:

Characteristics of participants, Philadelphia, PA, 2007–2011

Characteristic	Control Participants (n=274)
Age, years, mean (SD)	17.9 (3.5)
Race	
African American	98.5%
Caucasian	1.1%
Native American	0.4%
Currently enrolled in school	
<18 years of age	99.1%
≥ 18 years of age	44.2%
Receiving As/Bs in school	39.1%
Skipped school in past year	41.5%
Ever been suspended or expelled	69.0%
Currently employed	35.8%
Currently participating in structured activities	72.4%
Drank alcohol in past 30 days	34.6%
Used marijuana in past 30 days	23.8%
Ever been jumped	56.1%
Ever in a fistfight	91.9%
Ever been to hospital because of a fight	12.8%
Ever carried a weapon	39.1%
Ever been shot	4.1%
Ever been in a gang	11.6%
Ever been on juvenile probation	17.7%
Ever chosen travel route based on safety	73.9%
Frequency of choosing travel route based on safety	
Never	35.5%
Monthly	26.9%
Weekly	19.8%
Daily	17.9%
Neighborhood Environment Scale: perceived neighborhood disadvantage and disarray (range 0–20), median (IQR)	11 (8–13)

Characteristic	Control Participants (n=274)
Things I Have Seen and Heard Scale: exposure to violence (range 0–13), median (IQR)	7 (5–9)

Table 2:

Association between adolescent-adult connections and environmental exposures at home address, Philadelphia, PA, 2007–2011

Environmental exposure	Positive adult connection b [95% CI]	Supportive parental connection b [95% CI]	Supportive adult familial connection b [95% CI]
Vandalism	−0.20 [−0.51, 0.11]	−0.05 [−0.32, 0.23]	−0.09 [−0.36, 0.17]
Narcotics arrests	−0.24 [−0.59, 0.11]	−0.003 [−0.32, 0.31]	0.02 [−0.28, 0.32]
Disorderly conduct	−0.25 [−0.48, −0.01] *	0.005 [−0.21, 0.22]	−0.07 [−0.27, 0.13]
Alcohol outlets	−0.11 [−0.35, 0.14]	−0.14 [−0.36, 0.07]	−0.11 [−0.31, 0.10]
Vacant properties	0.06 [−0.27, 0.39]	0.05 [−0.24, 0.33]	−0.06 [−0.37, 0.22]
Recreation dept. facilities	−0.08 [−0.41, 0.25]	0.16 [−0.11, 0.44]	−0.04 [−0.31, 0.23]
Violence victimization	−0.04 [−0.41, 0.33]	−0.08 [−0.42, 0.26]	−0.09 [−0.41, 0.22]
Firearms in/around homes	−0.15 [−0.49, 0.19]	−0.01 [−0.30, 0.29]	−0.03 [−0.32, 0.25]

* $p < .05$

Table 3:

Differential environmental exposure along actual trip paths versus shortest potential trip paths among all study participants, and associations with positive adult connection, Philadelphia, PA, 2007–2011

	Among All Study Participants		Based on Presence of Positive Adult Connection	
Environmental Exposure	**Difference in Exposure Density Between Shortest and Actual Routes[a] 60ft buffer b [95% CI]**	**Difference in Exposure Density Between Shortest and Actual Routes[a] 660ft buffer b [95% CI]**	**Association Between Positive Adult Connection and Difference in Exposure Density[b] 60ft buffer b [95% CI]**	**Association Between Positive Adult Connection and Difference in Exposure Density[b] 660ft buffer b [95% CI]**
Crime				
Vandalism	**0.81 [0.46, 1.15]***	357.23 [−52.13, 766.59]	0.56 [−0.40, 1.53]	−125.23 [−1286.77, 1036.31]
Narcotics arrests	2.31 [−.035, 4.97]	**183.04 [52.53, 313.55]***	2.20 [−5.34, 9.74]	−113.05 [−483.06, 256.97]
Disorderly conduct	**0.74 [0.15, 1.33]***	**80.41 [8.34, 152.48]***	0.76 [−0.91, 2.43]	−132.61 [−336.35, 71.13]
Public drunkenness	0.09 [−0.02, 0.20]	0.51 [−0.10, 1.12]	0.07 [−0.24, 0.38]	0.46 [−1.28, 2.19]
Substance retailers				
Alcohol outlets	0.06 [−0.01, 0.14]	21.24 [−7.16, 49.64]	0.07 [−0.13, 0.28]	2.94 [−77.64, 83.53]
Features of urban landscape				
Vacant properties	0.92 [−0.10, 1.94]	549.86 [−34.39,1134.11]	0.94 [−1.96, 3.83]	460.86 [−1195.94, 2117.66]
Recreation department facilities	0.001 [−0.001, 0.003]	1.41 [−1.07, 3.89]	0.002 [−0.003, 0.01]	1.54 [−5.50, 8.58]
Murals	0.04 [−0.02, 0.11]	56.72 [−26.19, 139.64]	0.16 [−0.03, 0.35]	42.99 [−192.23, 278.21]

[a]Difference in exposure density is calculated as follows: Difference(density) = (total # points encountered within buffer per 1,000 feet traveled along short route) - (total # points encountered within given buffer per 1,000 feet traveled along actual route)

Mean difference in rate for each participant across all of their unique trips = (diff1 + diff2 + diff3 + diff4…)/#trips

[b]OLS regression assessed for associations between positive adult connection and differences in exposure density between shortest and actual routes

*$p < .05$

A portion of the results contained in this table have been presented in a previous publication outlining the exposure calculation methodology (Culyba, *Health and Place*, 2018).