People, Places, and Adolescent Substance Use: Integrating Activity Space and Social Network Data for Analyzing Health Behavior

Jeremy Mennis\(^1\) and Michael J. Mason\(^2\)

\(^1\)Temple University

\(^2\)Villanova University

Contact: Jeremy Mennis, Department of Geography and Urban Studies, Temple University, 1115 W. Berks St., 309 Gladfelter Hall, Philadelphia, PA 19122, Phone 215.204.4748, Fax 215.204.7833, Email jmennis@temple.edu

June 24, 2010

Forthcoming in *Annals of the Association of American Geographers*
Abstract

This research investigates the influence of place and social network characteristics on substance use among a sample of 215 urban, primarily African American, adolescents in Philadelphia, Pennsylvania. We utilize survey data that captures the places that adolescents perceive to be risky and safe, as well as their home location. The survey also captures the egocentric social network characteristics that are associated with each type of place for each adolescent. Place-characterization data included indicators of a variety of physical features we theorize may enhance or mitigate the likelihood of substance use, such as the locations of alcohol outlets, recreation centers, and violent crime. We employ multivariate Tobit regression to investigate the relationships of place and social characteristics with substance use behavior. Substance use was greater for males and older adolescents, but was associated with few physical features of adolescents’ home or perceived safe places. Substance use was enhanced by several characteristics of adolescents’ perceived risky places, such as commercial activity in distressed neighborhoods. In addition, the presence of substance users at an adolescent’s perceived risky place was associated with in increase in substance use. Substantial differences concerning gender and age were also observed. Girls and older adolescents tend to be more sensitive to social and place characteristics as compared to boys. This study highlights the importance of capturing activity space characteristics, perceptions of places, and social network data for investigating substance use, as well as for studies of other health and crime behaviors.

Keywords: substance use, drug abuse, social network, activity space, Tobit
Introduction

Recent national surveys conducted in the U.S. indicate an increase in the use of illicit drugs among middle and high school students (Johnston et al., 2009). Research has shown that urban youth are particularly vulnerable to early use and future abuse of illicit drugs and alcohol (Wright, 2004). Individuals who live in metropolitan areas, regardless of race or gender, are more likely than those in non-metropolitan areas to have used an illicit drug as well as alcohol during the past year (Johnston et al., 2009). African Americans living in the inner city are particularly at risk for substance abuse. For example, African Americans engage in greater lifetime use of marijuana as compared to white and Hispanic counterparts (CDCP, 2007) and there is evidence that as African Americans age, they suffer from substance abuse-related diseases at a greater rate as compared to other ethnic groups. The age-adjusted death rate from alcohol-related diseases for non-Hispanic African Americans is 10% greater than for the general population, while among African Americans 12 to 20 years old, alcohol use contributes to the three leading causes of death: homicide, unintentional injuries (including car crashes), and suicide (Wallace, et al., 1999). Given these risks, interdisciplinary and multi-faceted research into the pathways of substance use involvement for young African Americans should be a priority.

There is increasing recognition among substance abuse researchers that substance involvement is influenced by characteristics of the environment within which an individual resides and spends time (Jacobson, 2004; McLafferty, 2008). However, research in substance abuse that incorporates the influence of place is still in its infancy. We recognize several challenges to advancing the field in this regard. First, in the vast majority of research place characteristics are linked to substance abuse based on the location of an individual’s home. This
focus on the home is understandable, given that the emphasis of many studies is on the availability of drugs and/or alcohol, and one can assume that living nearby the opportunity to acquire these substances would affect substance use. In addition, many such studies use hospital, school, and other administrative records from which home address data may be easily culled. However, this focus on the home location does not take into account the other places that people frequent through work, school, and leisure. Such activities expose the individual to a variety of geographic factors that may influence substance use, but are not observed at the individual’s home. In addition, the places that people frequent outside the home are an expression of behavior that may be key to understanding substance use for that individual (Kwan et al., 2008).

Second, most studies have represented the characteristics of places based on a collection of objectively defined ‘facts’ about the neighborhood surrounding the individual’s home. These facts are often socioeconomic factors derived from U.S. Bureau of the Census data or the locations of easily recognizable geographic features that one theorizes influence substance use, such as the presence of liquor stores or crime. We assert that place-based substance abuse research should also address the perception of place. Intuitively, the influence of place on an individual’s behavior operates through the individual’s emotional interpretation of that place. Concepts such as a ‘high-crime neighborhood’ or ‘safe neighborhood,’ while ostensibly objectively measureable using crime and other data, may be experienced and interpreted completely differently by different individuals depending on their background and past experiences.

Third, while the influence of social interactions on adolescent substance use is well established (e.g. Mayes and Suchman, 2006; Valente et al., 2005), there has been little recognition in the literature on the interplay between social networks and place. We assert that
social influences are not aspatial but are embedded within place, and in fact play an important role in creating an adolescents’ sense of place through the social interactions that occur at particular locations. Indeed, an adolescent’s perception of a place is closely tied to the people with whom the adolescent interacts, and their attendant behaviors, at that location (Mason et al., 2009c)

Geographers, as experts in the interactions between people and the environment, are uniquely positioned to address these challenges. Recent calls for geographers to become involved in mental health research (Richardson, 2009) and the 2006 Symposium on Geography and Drug Addiction sponsored by the Association of American Geographers (AAG) and the National Institute of Health’s (NIH) National Institute on Drug Abuse (NIDA) (Thomas et al., 2008) reflect the growing awareness of the role that geographers can play in substance abuse research. It is also worth noting that the challenges listed above are not necessarily restricted to the field of substance abuse prevention but rather are applicable to a much broader research question concerning how the physical and social environments influence human behavior in a wide variety of health, crime, and other contexts (cf. Goodchild and Janelle, 2004). We note that questions of representing the perceptual, social, and daily lived experiences of individuals with regards to place has been central to the major critiques, and advances, in geographic information science and spatial analysis (Gilbert and Masucci, 2006; Kwan, 2002; Schuurman, 2006). Certainly, how place influences human behavior is one of the most fundamental questions of Human Geography, perhaps of all of Geography (cf. Turner, 2003), and, increasingly, of the social and health sciences generally.

The objective of this research is to address these challenges to substance abuse research through an investigation of the influence of place and social network characteristics on substance
use among a sample of 215 urban, primarily African American, adolescents in Philadelphia, Pennsylvania. For this purpose we utilize survey data that seeks to capture the activity spaces of adolescents by identifying the places that they perceive to be risky and safe, as well as their home location. The survey also captures the egocentric social network characteristics that are associated with each type of place for each adolescent. These data allow us to test for the influence of home and activity space characteristics on substance use, incorporate the perceptions of places as reported by each adolescent, as well as test the influence of place-based social network characteristics on substance use.

Environmental and Social Influences on Adolescent Health and Substance Use

Geographers have long held that place influences health behaviors and outcomes and that understanding regional variation, and especially inequities, in health outcomes is an important component of health research (Meade and Earickson, 2005). A helpful typology for considering how regional variation in health outcomes may be explained consists of compositional, contextual, and collective explanations (Macintyre et al., 2002). The compositional explanation captures the idea that individuals with similar characteristics often cluster together in space, such that one may observe spatial variation in health characteristics due to the spatial clustering in individuals who share common physical characteristics. Contextual explanations concern the features in the built environment that may influence health behaviors and outcomes, while collective explanations point to regional variation in customs, beliefs, and practices.

Many studies that have sought to investigate the influence of place on health have treated the influence of place characteristics as a residual influence left after the influence of other, typically individual-level, characteristics have been accounted for in models of health outcomes.
Clearly, however, the idea that space, itself, influences health is nonsensical – we must consider how characteristics of place, and not the abstract idea of location in Cartesian space, interact with the individual to produce health behaviors and outcomes (Cummins et al., 2007; Jones and Moon, 1993; Kearns, 1993).

Of course, the concept of place has a rich tradition in humanist and cultural geography, where the sense of place can be considered through the prism of emotional attachment and symbolic meaning that a place can invoke (Tuan, 1977). Place embodies not only the physical features of a place but also the cultures, traditions, and daily practices that occur at a place (Creswell, 2004). In the context of health, Gesler (1992) points out that various ways of characterizing place according to scholars in humanist and cultural geography can be useful for interpreting how place can influence health, including perspectives of emotional attachment as well as social, economic, and political structures. More recently, Kearns and Moon (2002) characterize the focus of place-based health geography as falling into categories of 1) studying health issues grounded in particular places, 2) landscapes as a construct for cultural factors of health, and 3) quantitative approaches, often employing multi-level modeling.

Cummins et al. (2007) criticize quantitative health geography research designs in which individual and place-based variables are allowed to ‘compete’ for the explanation of a health outcome. Instead, they call for ‘relational’ conceptualizations of how place influences health behaviors, some of the key features of which involve the idea of mobility of individuals, understanding power relations and culture, and the variable interpretation of contextual features among different people. These authors note that operationalizing an integrative approach to investigating the interplay between place and individual characteristics necessitates combining quantitative and qualitative approaches.
In the field of criminal justice, the structural socioeconomic and social characteristics of neighborhoods are known to influence adolescent deviant behaviors such as crime and substance use. Shaw and McKay (1948) initially put forth the idea that juvenile delinquency is in large measure influenced by social disorganization in inner-city neighborhoods, where indicators such as abandoned or dilapidated housing and criminal activity signify a lack of social control stemming from poverty, isolation from ‘mainstream society,’ and residential instability (Bursik, 1988). Others have argued that neighborhoods with concentrated disadvantage, in the form of low educational attainment, poverty, unemployment, and racial segregation, provide few positive role models and little opportunity to escape a cycle of poverty, and thus allow deviant behavior to proliferate (Boardman et al., 2001; Davis and Tunks, 1990; Massey and Denton, 1993; Nandi et al., 2006; Wilson, 1987). A lack of collective efficacy, i.e. a sense of being able to collectively solve problems as well as social cohesion among neighbors in a community, has also been suggested as facilitating deviant behavior through an absence of trust among members of a neighborhood, as well as the reluctance of neighbors to actively intervene and mitigate deviant behaviors (Sampson and Groves, 1989; Veysey and Messner, 1999).

Other researchers have focused not on structural neighborhood characteristics but on particular geographic features that produce landscapes of protection and risk that may mitigate or facilitate, respectively, deviant behaviors (Cummins et al., 2005; Mason et al., in press). The presence of alcohol sales (e.g. bars, liquor stores), for example, has been associated with substance use, poor substance use treatment retention, child maltreatment, violent crime generally, and gun violence specifically (Branas et al., 2009; Freisthler et al., 2007; Gruenewald et al., 2006; Stahler et al., 2009). Additionally, poor health outcomes have been associated with
access to features that can facilitate non-healthy behaviors, such as fast food restaurants and tobacco outlets (Cohen et al., 2003; Novak et al., 2006).

Subjective ratings of the physical and social characteristics of home neighborhoods have also been found to be important predictors of behavior such as substance abuse and mental health outcomes (Lambert et al., 2005; Latkin and Curry, 2003). Similarly, several qualitative studies have shown that perceptions of particular places are thought to influence health and health related behaviors, and are particularly suggestive of causal pathways linking place with health outcomes (Airey, 2003; Popay et al., 2003).

Research on social networks suggests that peer context is also a very robust predictor of adolescent substance use (Alexander et al., 2001; Bauman and Ennett, 1994; Mason, 2009; Mayes and Suchman, 2006; Unger and Chen, 1999; Valente et al., 2005). Approaches toward understanding the social processes of substance use uptake have typically focused on two distinct mechanisms: (a) social influence, indicating that adolescents’ substance use uptake occurs due to influence within the peer context, and (b), peer selection, where similar adolescents associate based on prior behaviors such as substance use (Hussong, 2002). Recent research, however, has blurred the lines between these mechanisms with prospective studies providing support for both mechanisms (Cotterell, 2007; Curran et al., 1997; Kirke, 2006). It now appears likely that social networks cannot be completely understood through a single linear, cause-effect model, but rather, like the interactive nature of social development, social networks have to be understood through bi-directional influences on actors, the network quality, and the context in which the social development processes are experienced (Bronfenbrenner, 1979; Cotterell, 2007; Kirke, 2006).
Theoretical Framework

Our research approach is predicated on the idea that that place is socially constructed, has multiple meanings, and is not merely a passive container in which things are simply recorded (Andrews, 1985; Horton and Reynolds, 1969; Kearns and Moon, 2002; Sack, 1997). We approach urban adolescent behaviors as being undergirded by place, tying together the mutually dependent and interconnected domains of our study (individual characteristics of the adolescent, as well as of the adolescents social network and ecological context of the built environment) through Stack’s (1997) geographic relational framework, where the domains are part of a dynamic and interdependent model. This model allows us examine the events and processes that occur in relation to a series of places for the adolescent (i.e. home and activity spaces). For example, adolescents’ social networks are constituted by the urban environment in which they operate, which in turn influences their interpretations of social meaning, sense of self, and ultimately their health behaviors. Therefore, we are seeking to further understand the relationships among urban youth, spatial and social behavior, and health outcomes.

Specifically, we examine the linkages between urban youths’ activity spaces and their social networks. In applying Bronfenbrenner’s (1979) social ecological model, we measure specific activity at the mesosystem, that is the interrelations among two or more settings in which the teen actively participates, such as the home, neighborhood, church, and school. We note that very little neighborhood effects research has addressed the ecological structure of urban adolescents’ daily routine activities and the associated temporal contingencies (Burton and Graham, 1998; Crouter and Larson, 1998; Sampson, 2003; Larson et al., 2001; Macintyre and Ellaway, 2003; Raudenbush, 2003). In addition, there has been little research in the social
network community that has examined social networks in relation to neighborhoods or the built environment (Berkman and Clark, 2003).

In our previous research with the present data set, we have found evidence of the influence of social networks on adolescent substance use, as well as support for differences in social influences on older versus younger adolescents, and for males versus females (Mason et al., in press). We have also found that for risky and safe places within adolescents’ activity spaces, spatial relationships to features such as alcohol outlets and crime events differ between substance users and non-users (Mason et al., 2009b). In the present study, we extend this previous research, which has been largely descriptive in nature, by integrating data on adolescents’ social networks, activity spaces, and features in the built environment within a single analysis. This integration of social and geographic domains serves as the basis for developing a predictive model of substance use severity, in which we test whether certain elements of each domain influences adolescent substance use.

Specifically, we consider three kinds of characteristics that may influence an adolescent’s substance use – individual characteristics, such as age and sex; ecological characteristics, such as the properties of the adolescent’s built environment; and social network characteristics, such as the substance use habits of the people with whom the adolescent spends time. We also consider that the ecological and social network characteristics are not fixed in space but extend over an adolescent’s activity space. Thus, an adolescent may be exposed to different ecological and social stimuli at different types of places. This conceptual model is shown in Figure 1, top, where the ecological and place-based social network characteristics of an adolescent’s activity space are viewed as combining with an adolescent’s individual characteristics to influence substance use. We also consider that the individual characteristics may moderate the influence
of ecological and social network characteristics on substance use (Figure 2, bottom). For example, it may be that social factors influence boys and girls substance use behaviors differently, or that the influence of ecological characteristics influences younger and older adolescents substance use behaviors to a lesser or greater degree (Mason et al., 2009[b]).

Of course, the nature of the relationships between ecological and social network characteristics with substance use may not be simply unidirectional, where substance use is directly influenced by individual, ecological, and social characteristics. We can consider two explanations for the relationship of ecological and social network characteristics to adolescent substance use. In the first, the character of the places where adolescents frequent influences their substance use behavior. Here, social and physical properties of the places themselves are believed to directly influence substance use. A second possible explanation lies with the adolescent – perhaps, for example, substance-using adolescents tend to seek out certain people and places with particular characteristics. For example, if one intends to use drugs or alcohol, it makes sense to frequent places where and with whom substance use is tolerated. Here, the characteristics of the place and the social network are ascribed to the choice of the adolescent, such that the adolescent’s social network and ecological properties don’t necessarily influence the adolescent’s substance use, but are instead a consequence of the characteristics of the adolescent’s substance use.

We also consider a possibility that there is some feedback mechanism involved in the influence of place characteristics and behavior. For example, a substance using adolescent may choose to frequent a place far from a police station or nearby a corner store selling packaged beer to facilitate his or her substance use. Consequently, the negative influences associated with that place, potentially including the people who are with the adolescent there, then encourage the
adolescent towards increasing substance use. Such feedback mechanisms support the idea that interactions between neighborhood and social contexts and psychological processes may interact to produce a trajectory of substance use and abuse.

For instance, we note that many urban youth are disproportionately exposed to trauma (e.g., violence, crime) which increases vulnerability to substance use (Costello et al., 2002; Kilpratrick et al., 2000). Specifically, early exposure to trauma and subsequent development of symptoms of post traumatic stress disorder (PTSD) can interfere with emotional regulatory tasks and lead to further internalizing problems (Lubit, 2005; Mayes and Suchman, 2006). These psychological problems can consequently interfere with school performance and can contribute to withdrawal and negative attitudes toward school. Negative attitudes toward the educational environment increase the likelihood of associating with peers who have lower commitment to school, share poor academic achievement, lack adherence to conventional societal norms, and are thereby more accepting of the use of substances as a coping or social activity (Wills et al., 2001).

Data and Methods

Participants and Procedures

The sample is composed of 301 adolescent primary care patients seeking general health services at a public health clinic in Philadelphia, Pennsylvania. Participants in the study were required to be between 13 and 20 years of age, live in Philadelphia, be free from major mental health disturbance, and speak English. Minor patients had to be accompanied by parents or legal guardians capable of providing informed consent. Written informed consent was obtained from all parents and/or adolescent participants. Nominal incentives were used to acknowledge
participants’ time and effort and the study’s consent rate was 90%. The second author’s university and the city of Philadelphia Health Department’s institutional review boards approved the research protocol and the study received a federal certificate of confidentiality.

Participants completed a comprehensive battery of psychosocial and geographic study measures. Measures were administered in private (i.e., in a separate room from parents to protect patient confidentiality and obtain more valid data) and the procedure generally lasted 45 minutes or less. The sample was 87% African American with 13% self-identified as mixed or other race/ethnicity. The majority (60%) of the sample was female which corresponds with other primary care gender distributions (Mason et al., 2004). The high African American rate is representative of the urban area served by the health care center. Nearly one third (30%) of the subjects were living below the poverty line and 14% were on public assistance.

All outcome, individual, ecological, and social network variables used in the present analysis are described in Table 1 and descriptive statistics for these variables are reported in Table 2. Individual level variables include age and sex. Note that because the vast majority of subjects self-identified as African American, there is not sufficient variation in the race variable to yield useful information, and it was therefore not included in the analysis.

Substance Involvement Measure

Substance involvement was measured with the Adolescent Alcohol and Drug Involvement Scale (AADIS) (Moberg and Hahn, 1991). The AADIS is a brief measure of the level of alcohol and drug involvement in adolescents for use as a research tool and is highly accurate in differentiating between those who do not have any substance use disorders and those that have at least one (Winters et al., 2001). The AADIS has favorable internal consistency reliability
(Cronbach’s alpha 0.94) and correlates highly with self-report measures of substance use \((r = 0.72)\) and with clinical assessments \((r = 0.75)\), and with subjects’ perceptions of the severity of their own drug use problem \((r = 0.79)\). The AADIS is a brief screening tool and therefore indicates the likelihood of a substance use disorder, it is not diagnostic. However, it is useful for research purposes by placing subjects into three categories: (a) Those reporting no alcohol or drug use, with scores of 0; (b) Those reporting alcohol and/or drug use, but use that does not reach the threshold for substance use disorder based on the DSM-IV criteria, with scores of 1-36; (c) Those reporting alcohol and/or drug use which is likely to reach the DSM-IV criteria for either substance abuse or dependency, with scores of 37 or higher.

AADIS score forms the outcome variable in this analysis, SUBSTANCEUSE. Substance use data was purposely collected to create two groups equally divided by substance users \((n = 151)\) and non-users, defined as those who report never having used substances or having not used substances within the last year \((n = 150)\). Alcohol and marijuana made up the vast majority of substances the subjects reported using at least once, with 50% reporting alcohol use and 37% reporting marijuana use. Other substances used included LSD, amphetamines, cocaine/crack, barbiturates, PCP, inhalants, and valium, though the percentage of adolescents using each these substances totaled less than 3% of the sample. None of the subjects had used heroin.

**Social Network Measure**

Egocentric social network data was gathered using the Adolescent Social Network Assessment (ASNA) (Mason et al., 2004). The ASNA captures information on each person’s close personal contacts, their strong ties which constitute their social networks. An overview of the data collection process is shown in Figure 2. Adolescents are asked to name the people with
whom they have contact at least once per month and with whom they have a “meaningful relationship.” These associates are referred to as “alters,” according to the social network literature convention. Subjects are asked whether they know if each alter uses substances and how often and whether they have been directly or indirectly influenced to use or not to use substances by each alter. Subjects are asked about positive activities such as receiving help with school or transportation, as well as negative activities such as engaging in illegal or dangerous behaviors.

Responses are given weighted values of 1-6 forming a possible range of -14 to 14, with higher scores indicating more protection and lower scores indicating more risk. Weights were based upon our research that has shown risk for negative mental health outcomes increase with one substance user in a network, and risk is substantially elevated with one daily substance user in a network (e.g. three-fold increase) (Mason, 2009; Mason, et al., 2004). These procedures follow those widely used and accepted in the social network field (Burt, 1984; Cotterell, 2007; Liebow, et al, 1995; Marsden, 1990; Valente, 2003). The ASNA has favorable internal consistency reliability (Cronbach’s alpha 0.84) and correlates significantly in the expected direction with self-report measures of substance use ($r = -0.66$). Given these social network data, we developed a weighted scoring procedure that forms a subject’s NETQUALITY variable value, as shown in Figure 2. Negative values indicate increased risk for substance use and positive values indicate increased protection from substance use.

Adolescent Activity Space Measure

Adolescents’ activity space data were collected via the Ecological Interview, a structured interview that uses a method known as ‘Free Listing’ where participants are asked to list and
describe all the elements that are part of a particular domain of interest, in this case weekly locations (Weller and Romney, 1988), as well as the ‘Recall Method’ (Verma and Saraswathi, 1992) where respondents report on their activities in sequential order for a given reference period, in this case one week. Once the list is created, subjects are then asked to identify the safest (i.e. the safest place from harm, danger, or the likelihood of engaging in risky or dangerous activities) and riskiest (i.e. the place in which the adolescent would be most likely to engage in risky or dangerous activities, cause trouble, or do illegal activities) place from their list of places. Subjects were also asked when (i.e. weekdays versus weekends, the time of day) they go to each place. When they identified a location as either safe or risky, subjects were asked, ‘What makes this place safe/risky?’ Answers were recorded as brief narrative responses for why adolescents perceive particular places in their activity space as safe or risky. All locations were geocoded using streets data provided by the City of Philadelphia.

Note that all the explanatory variables in the analysis, with the exception of SUBSTANCEUSE, MALE, and AGE were calculated separately for the home, safe, and risky places listed for each adolescent. The social network characteristics and the activity space of each adolescent were linked together via the location of the places where subjects interacted with each social network alter. Subjects were asked with which alter they interact at each (home, safe, or risky) location. Knowing the risk and protective behaviors of each alter, and knowing where these alters interact with the adolescent, allows for a specific place-based social network quality value to be derived, i.e. a NETQUALITY variable value was calculated for each subject’s home, safe, and risky place.

Of the 301 surveyed adolescents, complete (no missing) data could be obtained for 215 adolescents, which forms the sample for the present study. Though we were disappointed at
having to eliminate 86 subjects from the present analysis, it did not make sense to incorporate subjects with incomplete activity space or other data. Note that many of the activity space locations were given according to relative and/or qualitative descriptions of landmarks such as stores or parks. Obviously, geocoding such information is not a trivial task, and requires substantial manual labor. Even with this effort, however certain places for certain subjects could not be geocoded accurately, or had other missing data. A Mann-Whitney U test reveals there is not a significant difference in the outcome variable SUBSTANCEUSE between the 215 subject sample and the 86 subjects who were eliminated (U=8271.50).

*Ecological Data*

We collected data on a variety of geographic feature that we theorized influenced adolescent substance use. These geographic features are intended to capture characteristics of place that signify environments of risk and protection. We have carefully chosen these features from our own previous research on substance use behaviors among other populations (Mennis and Mason, 2010; Mason et al., 2004; Mason et al., 2009a; Stahler et al., 2007; 2009), as well as descriptive research with the present data set (Mason et al., 2009[b], in press).

We collected and geocoded data on the locations of potential negative influences, particularly features that signify commercial activity in socioeconomically distressed neighborhood, as these locations often serve as the focal point for violence and disruptive behavior in distressed neighborhoods, and have been shown to be related to substance use outcomes in our own previous research (Stahler et al., 2007). Data on all bars and stores selling packaged beer were acquired as a list of addresses from the Pennsylvania State Liquor Control Board, a state agency charged with licensing all alcohol sales in the state. We also acquired lists
of address locations for all check cashing stores and pawn shops in Philadelphia from the digital yellow pages. Figure 2 shows a map of these negative features in West Philadelphia. The variable NEGATIVE encodes the minimum distance of each subject’s home, safe, and risky location to the nearest bar, store selling packaged beer, check cashing store, or pawn shop. We also incorporate a variable that captures the presence and degree of violent crime. These data were acquired from the Philadelphia Police Department and contained block-level addresses for arrests for assaults, robberies, and homicides during 2000-2002. These data were geocoded and the density (arrests/km²) for the area within 500 meters of each home, safe, and risky location was calculated.

We also collected data on features that offer alternative activities to substance use. The locations of programs that provide activities intended to deter adolescents from deviant behaviors were acquired from the City of Philadelphia and geocoded, including address data on after-school programs, head start and head start partner programs, and recreation centers. Figure 3 shows a map of these activities features in West Philadelphia. The variable ACTIVITIES encodes the distance to the nearest of these program locations for each subject’s home, safe, and risky place. We also acquired and geocoded data on the locations of police stations, theorizing that police stations would act as a deterrent to risky behavior nearby. The variable POLICE encodes the distance to the nearest police station for each home, safe, and risky location for each subject.

Analytical Approach

Multivariate relationships among the explanatory variables and substance use are assessed using Tobit regression (Tobin, 1958). The substance use variable has a distribution
where non-substance users have a value of ‘0’ and substance users have an index value ranging from 1-43. The substance use index can be viewed as capturing propensity for substance use, where non-users can have a negative degree of propensity that is left censored at zero. Ordinary Least Squares (OLS) regression is inappropriate for substance use data such as these, and may result in estimated values of the dependent variable less than zero, biased parameter estimates and standard errors, and heteroskedastic error terms (Frone et al., 1994). We follow the example of other substance use researchers who have employed Tobit regression to analyze substance use data of this nature (Drake et al., 1998; Frone et al., 1994; Wryobeck et al., 2006).

We first consider the conceptual framework described in Figure 1, top. Our analysis proceeds by initially testing for significant relationships among ecological explanatory variables with substance use within the different types of activity space places – home, safe, and risky places. The intent of this approach is to identify the salient ecological characteristics of each type of place, so that those characteristics may be combined with social network and individual characteristics in a coherent and parsimonious model later on.

We then calibrate a three stage regression equation using only the significant variables from the home, safe, and risky models, where first the significant ecological variables are added, then the place-based social network variables, then the individual variables. For all models we are careful to consider issues of multi-collinearity using the Variance Inflation Factor (VIF) statistic and correlations between explanatory variables. Due to these considerations we include only the risky place social network quality variable. While each of the home, safe, and risky place variables are significantly and negatively correlated with substance use, they are also significantly and positively correlated with each other. The VIF statistic of models including all three social network variables indicates problems of multicollinearity. Of the three types of
places, the risky place social network quality variable is correlated most strongly with substance use (-0.449), which suggests that although an adolescent’s social network in general influences substance use, those people he or she spends time with at their perceived risky place are most influential on the adolescent’s substance use.

We then address the issue of moderation by individual characteristics as shown in Figure 1, bottom. While the use of interaction terms is often used to investigate moderation, this approach would be inefficient here, as we have many individual, social, and ecological variables, which would result in an unwieldy number of interaction terms. We therefore investigate this issue by performing a subgroup analysis, where we divide the sample population into four groups: younger girls (age 13-16), older girls (age 17-20), younger boys (age 13-16) and older boys (age 17-20). We choose 16-17 as the break point in age because it is a key transition period in adolescence toward independence and also has the convenience of providing a roughly even split in counts among younger and older adolescents in the sample.

We also review the narrative responses of the adolescents to the survey questions about why certain places are perceived as risky and safe. These narratives are a rich source of information about the lived experience of each adolescent and suggest the nature of the relationship between what actually occurs at particular places, socially and ecologically, that creates feelings of safety or risk. We therefore use the narrative responses to supplement and provide insight into interpreting the statistical analysis results.

Results and Discussion

Characteristics of Home Places
Table 3 reports the results of the regressions run with the ecological variables. Note that each of the three models reported in Table 4 use a similar set of types of variables, but derived from a different set of location-based observations. So, for instance, Model 1 uses the VIOLENTCRIME variable as calculated from adolescents’ home locations, whereas Model 2 uses the VIOLENTCRIME variable as calculated from the adolescents’ safe locations.

Model 1 indicates that the ecological characteristics of adolescents’ homes appear to have little association with substance use. We speculate substance use is driven more by what is happening inside the home, rather than with geographic features external to the home. Interestingly, the sign of the one home place-based ecological variable that was significant, ACTIVITIES, was counter-intuitive to what one might expect. While geographic features such as after-school programs and recreation centers may be expected to provide opportunities for adolescents to engage in healthy and productive activities instead of using substances, our results suggest just the opposite – living in proximity to these activities is associated with an increase in the likelihood of substance use. We emphasize, however, that these results do not necessarily imply that recreation centers and the like are causing substance use, only that substance use is more likely for adolescents living nearby these features. It is possible that the location of recreation centers is acting as a proxy for some other causal mechanism, or perhaps living nearby these features, which have a strong social purpose and act as gathering places for many adolescents, facilitates social influence to use substances.

We note that these results agree with our own previous research on a different sample of adolescents living in the Washington, D.C. region, where we found that proximity to boys and girls clubs (i.e. recreational facilities for teenagers) was associated with increased alcohol use (Mason and Mennis, 2010). We speculated then that recreation centers were acting as a proxy
for spatial patterns of race and socioeconomic status that were associated with certain types of substance use.

In the present research, adolescents’ narrative responses to the Ecological Interview suggest that recreation centers, parks, playgrounds and similar types of places can be risky for many subjects in this population because they are public spaces where people who don’t know one another can mix, often with violent results. For example, one subject who categorized the recreation center as a risky place did so because “there’s a lot of violence” and there are “shootings there.” Another subject said “there’s [sic] a lot of guys there that think they are tough.” Yet another said the recreation center was risky because he is, “around a lot of people that get involved in risky activities.” Thus, we speculate that these activity-providing features are associated with negative social influences, which are tied to increased substance use. Unfortunately, these negative social influences appear to outweigh the positive intended function of these features as providing a safe and positive gathering place for urban youth.

**Characteristics of Safe Places**

Results of the model of safe locations (Table 3, Model 2) suggest there is little relationship between the neighborhood characteristics of adolescents’ safe places and substance use, with the exception that those adolescents who go to their safe place exclusively on the weekdays are less likely to be substance users. This is also perhaps counter-intuitive; however, many of the adolescents who stated that they went to their safe place on the weekdays did so because their safe place is their school, which, of course, they attend exclusively during the week. The WEEKDAY variable may thus be serving as a proxy for the protective characteristic
of a safe school – those students who think of their school as their primary safe place are less likely to be substance users (Mason and Korpela, 2009).

Narrative responses of adolescents suggest that the perception of school as a safe place mostly concerns the presence of authority figures, such as teachers and guards, as well as rules that are strictly enforced. These characteristics provide a sense of security, safety, and structure. One adolescent says, for example, that “you have staff and people that watch over you.” Another says that, “there are rules and adults there.” Other typical responses include “teachers care about my safety” and “[there are] lots of security guards there.”

Unfortunately, school is not necessarily a safe place for many adolescents in the sample. School appears listed as a safe place 21 times in the survey, with most reasons focusing on the fact that schools have security guards and that there are caring adults present in the form of teachers and other staff. However, school also appears listed as a risky place 37 times, for reasons similar to those given for the riskiness of recreation centers. Adolescents gave reasons for perceiving schools as risky such as “there are so many students [of] many different backgrounds,” “students bring weapons and fight,” students are “difficult to trust,” and “you don’t know what someone might do.”

**Characteristics of Risky Places**

Unlike with adolescents’ home and safe locations, several of the ecological characteristics of adolescents’ risky places are associated with the degree of substance use (Table 3, Model 3). The NEGATIVE and POLICE variables are both significant – as an adolescent’s perceived risky place gets farther from a negative feature and closer to a police station, the degree of substance use decreases. The time of day that an adolescent visits their perceived risky
place is also associated with substance use, where adolescents’ who go to their risky place exclusively during the day (before 6 pm) have a lower degree of substance use.

Narrative responses about the nature of the risky places for those adolescents with the greatest substance use (those who are at-risk for substance use disorder with an AADIS value of greater than 36) support the idea that substances users’ perceptions of risky places are associated with certain features in the built environment related to drugs and violence. Consider the following typical narrative responses given for the reason a place is perceived as risky among adolescents with the highest AADIS values. One substance abuser who identifies his risky place as a neighborhood street corner says that “[it’s] about turf – who’s block, who’s corner in terms of drug activity [and] violence.” We note that these street-corner hang outs tend to be in commercial areas so that they are nearby one of the features that compose the NEGATIVE variable, such as a store selling packaged beer or a check cashing store. Several other substance abusers’ risky place is a bar, because of the presence of drugs, weapons, and the occurrence and/or threat of violence. Another common risky place location of substance abusers relates to commercial activities, such as a Chinese food restaurant, corner store, and shopping mall. About corner stores (some of which likely sell packaged beer), substance abusers state that “people do drugs and stuff around there,” “there isn’t nothing but drug dealers [sic],” and “[I] can get shot there.”

Many of the subjects’ explanations for risk were a blend of social and environmental reasons, such as, “There’s [sic] lots of dangerous people around and it’s a wide-open place.” A common environmental reason for the safety or risky quality of a location was related to the concepts of containment (e.g. “I am inside where it’s safe”) and exposure (e.g. “You’re wide open to whoever’s there”). These reasons can be seen as critical and important survival skills for
an often dangerous city. Using phrases like “lots of killing going on” or “anything can happen,” or, “it’s crazy there” to describe risky settings represent typical responses for many adolescents in our study. Thus, risky locations, whatever their type (school, friend’s home, park), appear to be perceived as risky due to interactions between risky people and risky settings.

*Integrating Individual, Social Network, and Ecological Characteristics*

Table 4 shows the results of the models that include the significant variables from the models shown in Table 3. Model 1 in Table 4 shows that when the significant variables of perceived risky places are included with ACTIVITIES of home places and WEEKDAY of safe places, all variables remain significant ($p<0.05$), with the exception of safe place WEEKDAY. The introduction of the risky place NETQUALITY in model 2 enhances the fit of the model and causes risky place DAYTIME to lose significance. As expected, a greater social network quality is associated with a lower degree of substance use.

Model 3 adds AGE and MALE to the model, consequently enhancing the fit of the model over model 2, and causing the risky place POLICE variable to lose significance, though the home place ACTIVITIES and risky place NEGATIVE variables remain significant. Being older and male is associated with a higher degree of substance use. This finding is consistent with national representative survey data that shows males and older adolescents use more substances than females and younger teens (Johnston et al., 2009).

It is interesting that the presence of variables indicating the adolescent’s age and sex, as well as the social network quality in the perceived risky place, causes the explanatory variables related to the day-of-the-week and time-of-day that the adolescent visits certain places to lose significance. For risky place DAYTIME, it is likely that older adolescents, and perhaps males,
have greater independence to stay out at night than younger adolescents, as older children typically are granted more freedom from their parents’ to come and go as they please. Particularly for those adolescents’ over the age of 17, their schedules may be completely independent of their parents’ rules. Thus, the variance in the outcome explained by DAYTIME for perceived risky places may be explained by AGE. Likewise, we speculate that the age of the adolescent is related to the safe place WEEKDAY variable. The mean age for adolescents who go to their safe place primarily on weekdays is 15.8 years, whereas for adolescents who do not go to their safe place primarily on weekdays it is over a year older at 16.9 years. A Mann-Whitney U test indicates this difference is significant ($U=2,288, p=0.01$).

If indeed the safe-place WEEKDAY variable is acting as a proxy for perceiving school as safe, the results of model 3 are likely due to the fact that younger adolescents are more likely to perceive their school as safe as compared to older adolescents. It is possible that the ecological characteristics of adolescents’ routine locations are also influenced to some degree by the age and sex of the adolescent. For example, older adolescents may be more likely to frequent perceived risky places that are located nearby commercial areas and far from police stations. This does not, of course, negate the association of these ecological characteristics with substance use, nor do we believe that the association of certain ecological characteristics with substance use is merely a ‘byproduct’ of age and sex characteristics. Rather, we believe these results suggest that ecological and social network characteristics of adolescents’ routine locations interact with age and sex to produce substance use outcomes. In other words, individual, ecological, and social network characteristics make up a constellation of properties that may influence substance use.
Sub-Group Analysis

We investigate this issue further by testing whether the influence of ecological and social network characteristics on substance use differs for age and sex-specific subgroups of adolescents: older girls, younger girls, older boys, and younger boys. Tobit regression is applied to each subgroup individually using the explanatory variables reported in Table 4, except with age and sex variables removed. Table 5 reports the results. Clearly, the influence of ecological and social network variables on substance use differs among the different subgroups. In fact, these results suggest that the relationships between certain explanatory variables and substance use are driven by certain subgroups of the sample. Generally, older adolescents exhibit a stronger relationship between ecological characteristics and substance use as compared to younger adolescents. Girls exhibit a stronger relationship of social network characteristics with substance use as compared to boys.

Interestingly, none of the ecological variables are significantly \((p<0.05)\) related to substance use for the younger boys and girls, with the exception of risky place \(\text{NETQUALITY}\) for younger girls. Older girls appear to be influenced by proximity to certain features of their perceived risky places, as indicated by the significance of the \(\text{NEGATIVE}\) and \(\text{POLICE}\) variables. Substance use in older girls also exhibits a strong relationship with the social network characteristics at those risky locations. Substance use in older boys, on the other hand, is associated with the presence of after-school programs and recreation centers nearby their homes. It is also interesting that for older girls \(\text{WEEKDAY}\) is significant, where going to the safe place on a weekday is associated with a lower degree of substance use.

These results suggest a qualitative difference in the way that ecological characteristics influence substance use in girls and boys. For girls, the social and physical characteristics of the
risky place appear to play a substantial role in substance use. As we note above, we cannot be sure from the present research whether these ecological characteristics influence behavior or whether adolescent girls who use substances tend to seek out the company of other substance users in risky places with these characteristics. However, we speculate that it is a combination of these processes, which may reinforce each other. Boys, however, seem to be more sensitive to mixing with larger groups, (other than their close peers that constitute their social networks), of adolescents. Hence, living nearby a recreation center or other location that provides the opportunity to mix with other adolescents in an unstructured environment is associated with greater substance use.

**Conclusion**

We acknowledge several limitations of this study. One limitation is that the sample is racially homogeneous, being composed almost entirely of African American adolescents, with a smaller variation in socioeconomic status than exists throughout the city of Philadelphia and certainly throughout the metropolitan area. This racial, and to a lesser extent economic, homogeneity in the sample prevents us from fully addressing the influence of race and class on substance use, and its interaction with social network and other place-based characteristics. However, as an exploratory investigation our study was designed to describe our sample of interest (urban adolescents presenting for routine primary health care services). Our study builds on our previous research in other large urban settings, such as Washington, D.C. (Mason and Mennis, 2010; Mason et al., 2009c; Walker et al., 2006), to provide evidence of the relationships between environmental and social contexts with adolescent substance use.
Another limitation concerns the cross-sectional design of the study, which limits us from fully testing the causal hypotheses that were advanced in our theoretical framework. As we discussed above, we cannot necessarily distinguish between the influence of social networks and place characteristics on substance use and the tendency of substance using adolescents to choose certain types of people with whom to associate and certain types of places to frequent. Additionally, while this study provides evidence that age moderates the influence of social network and place contextual effects on substance use, the lack of longitudinal data limits our understanding of how these contextual mechanisms operate for individuals over time. It would be particularly beneficial to be able to estimate the duration and malleability of these findings across developmental periods. Of course, we note that these limitations are not specific to our research but extend to the vast majority of social and environmental contextual effects studies that employ cross-sectional data.

This study has also not addressed the psychological characteristics and family dynamics of adolescents and the influence of these factors on substance use. The survey data contain a variety of measures of psychological characteristics and family dynamics, including indicators of post traumatic stress disorder (PTSD), parental substance use, and measures of emotional stability and attitude toward school. As we begin to incorporate the psychological measures as explanatory variables of substance use, we also need to consider more sophisticated conceptual models of how place, social networks, and the characteristics of the individual adolescent and his/her family dynamics interact to produce substance use behaviors. It is likely insufficient, for example, to hypothesize competing direct effects of each of these types of influences on substance use. For this purpose we intend to employ tests of mediation, as in statistical models.
of substance use that will allows us to test whether, say, evidence of psychological trauma mediates the influence of neighborhood and family stressors on substance use.

Despite these limitations, our study suggests relationships between social and spatial contexts and adolescent substance use that have been heretofore unexamined, where substance users’ perceived risky places are found to have different geographic and social characteristics than those of non-users. We consider that adolescents’ choose, at least to some extent, where and with whom they spend time. At the same time, substance use behavior is influenced by the environment and people with whom one interacts. Thus, adolescents’ spatial and social contexts may be considered an expression of, as well as an influence on, substance use behavior. Perceptions of places also appear to play an important role in understanding adolescent substance use, where perceptions of risk due to unstructured social mixing and metaphors of exposure at locations such as school and commercial places are associated with substance use. We note that users’ risky places do indeed differ from non-users’ in some objective measures of risk, such as proximity to bars and other features. However, perception itself may also be considered to be a characteristic of the adolescent that is the filter through which a place is experienced. For example, a downtown shopping mall was listed by several adolescents as a risky place and by several others as a safe place. Whether this mall is indeed a risky place (and if so, how) is an open question, but clearly the perception of risk for this location varies substantially among individuals. Whether a reflection of some objective measure of riskiness or not, perceptions of risk within an adolescent’s activity space, as expressed through feelings of vulnerability, fear of unstructured social interaction, and exposure to violence, is likely indicative of psychological trauma that relates to substance use.
This research also offers several conclusions that have important implications for investigating contextual influences on adolescent substance use, and indeed, for many studies that seek to model the influence of place on individual behavioral outcomes. First, it is important to not only incorporate spatial information about an adolescent’s home location, but also about their activity space locations. In this study, we found few relationships between characteristics of adolescents’ home or safe places with substance use. However, substance use was clearly associated with several geographic characteristics of places that we theorized may encourage substance use and that adolescents perceived as risky.

We note that the overwhelming majority of studies that investigate the impact of place on human behavior have operationalized the concept of neighborhood influence by focusing on individuals’ home addresses and then matching those home locations with neighborhood characteristics. Our research clearly suggests that such an approach may be lacking, certainly for the present study, but likely for many investigations that focus on complex behaviors that are expressed and influenced by the daily activities of individuals. Such daily activities are, of course, not limited to the home for most people. Many, if not most, of the behaviors that social scientists investigate, whether concerning crime, health, or otherwise, are expressed and influenced by interaction with the environment. Thus, we should expect that neighborhood influences outside the home would impact behavior. This research thus supports recent research in geographic information science and related fields that seek to capture quantitative activity space data as a component of investigating people’s daily lived experiences (Golledge and Stimson, 1997; Kwan and Ren, 2008; Sherman et al., 2005).

Second, when considering the influence of place on substance use, understanding how people perceive of places is just as important as collecting ‘objective’ data on socioeconomic
characteristics and the physical features that are located nearby that place. Our research suggests that perceptions of risk and safety that adolescents attach to places play a key role in how places may affect substance use behaviors. Moreover, qualitative data that capture the underlying reasons for why places may be perceived as risky or safe are key to understanding the links between characteristics of places and their impact on substance use.

Third, social networks matter when considering the influence of place on adolescent substance use. We argue here that with whom one spends time with at a location constitutes that place as much as any physical feature at that location. In addition, social influences on adolescent substance use operate in conjunction with other characteristics of place, not independently. For instance, we found that while social characteristics at the home location were associated with substance use in a univariate context, the characteristics of the people at adolescents’ risky locations were most influential of all the place-based social network variables we considered. Conversely, protective social influences at adolescents’ risky places appear to have a substantial positive impact to mitigate substance use.

Finally, this research suggests that social network and ecological contextual effects are moderated by sex and age in particular ways, where older adolescents and girls generally appear to have greater associations of substance use with certain social and environmental characteristics. Such findings have implications for directing future research, where specific contextual mechanisms related to substance use may be investigated for particular populations, as well as for substance use treatment, where interventions into the contextual factors related to substance use may be tailored to certain populations.

Acknowledgements
The project described was supported by Award Number R21DA020146 (Michael Mason, P.I.) from the National Institute on Drug Abuse. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Drug Abuse or the National Institutes of Health.

References


social and material context: generation and interpretation of ecological data from routine and non-routine sources. *Health & Place, 11:* 249-260.


Raudenbush, S.W., 2003. The quantitative assessment of neighborhood social environment. In I. Kawachi & L. Berkman (Eds.), *Neighborhoods and Health* (pp. 112-131). Oxford University Press.


*Correspondence:* 1115 W. Berks St., 309 Gladfelter Hall, Department of Geography and Urban Studies, Temple University, Philadelphia, PA 19122, e-mail: jmennis@temple.edu (Mennis);
Department of Education & Human Services, Villanova University, St. Augustine Center, 800 Lancaster Avenue, Villanova, PA 19085, e-mail: michael.mason@villanova.edu (Mason).
List of Figures

Figure 1. Conceptual framework for modeling influences on adolescent substance use. Top diagram shows direct effects of individual and place-based ecological and social network characteristics on substance use. Bottom diagram shows effects of place-based ecological and social network characteristics on substance use as moderated by individual characteristics.

Figure 2. Data collection procedure for activity space and place-based social network quality data (Mason et al., 2009)

Figure 3. Geographic features associated with commercial zones in West Philadelphia, proximity to which is theorized to enhance adolescent substance use.

Figure 4. Geographic features in West Philadelphia that provide recreational activities for adolescents, and which are therefore theorized to suppress adolescent substance use.
### Table 1. Variables used in the analysis.

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>SUBSTANCEUSE</td>
<td>Continuous variable indicating degree of substance use</td>
</tr>
<tr>
<td>Individual</td>
<td>MALE</td>
<td>Dichotomous variable encoding whether the adolescent is male</td>
</tr>
<tr>
<td></td>
<td>AGE</td>
<td>Continuous variable encoding the age in years of the adolescent</td>
</tr>
<tr>
<td>Ecological</td>
<td>VIOLENTCRIME</td>
<td>Continuous variable indicating density of arrests for violent crime within 1 km</td>
</tr>
<tr>
<td></td>
<td>NEGATIVE</td>
<td>Continuous variable encoding the distance to the nearest bar, store selling packaged beer, check cashing store, or pawn shop (km)</td>
</tr>
<tr>
<td></td>
<td>ACTIVITIES</td>
<td>Continuous variable encoding the distance to the nearest recreation center, afterschool program, head start, or head start partner program (km)</td>
</tr>
<tr>
<td></td>
<td>POLICE</td>
<td>Continuous variable encoding the distance to the nearest police station (km)</td>
</tr>
<tr>
<td></td>
<td>DAYTIME</td>
<td>Dichotomous variable encoding whether the adolescent typically goes to a safe or risky place only before 6 pm</td>
</tr>
<tr>
<td></td>
<td>WEEKDAY</td>
<td>Dichotomous variable encoding whether the adolescent typically goes to a safe or risky place only during the week (i.e. Monday-Friday)</td>
</tr>
<tr>
<td></td>
<td>HOMESAFE</td>
<td>Dichotomous variable encoding if the home location of the adolescent was also chosen as a safe location</td>
</tr>
<tr>
<td>Social Network</td>
<td>NETQUALITY</td>
<td>Continuous variable indicating the overall risky versus protective characteristics of the adolescent’s social network, as derived from the ASNA, where higher values indicate greater protection</td>
</tr>
</tbody>
</table>
Table 2. Descriptive statistics (N=215).

<table>
<thead>
<tr>
<th>Place</th>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>SUBSTANCEUSE</td>
<td>0</td>
<td>67</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Individual</td>
<td>AGE</td>
<td>13</td>
<td>20</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>MALE</td>
<td>Yes = 77 (36%), 138 (64%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>VIOLENTCRIME</td>
<td>42</td>
<td>789</td>
<td>421</td>
<td>171</td>
</tr>
<tr>
<td>NEGATIVE (km)</td>
<td>&lt;0.01</td>
<td>0.72</td>
<td>0.21</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>ACTIVITIES (km)</td>
<td>&lt;0.01</td>
<td>0.80</td>
<td>0.31</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>POLICE (km)</td>
<td>0.11</td>
<td>3.56</td>
<td>1.14</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>NETQUALITY</td>
<td>-29</td>
<td>70</td>
<td>10</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>SAFEHOME</td>
<td>Yes = 117 (54%), No = 98 (46%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>VIOLENTCRIME</td>
<td>6</td>
<td>1,007</td>
<td>418</td>
<td>187</td>
</tr>
<tr>
<td>NEGATIVE (km)</td>
<td>&lt;.01</td>
<td>0.77</td>
<td>0.21</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>ACTIVITIES (km)</td>
<td>&lt;.01</td>
<td>1.14</td>
<td>0.30</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>POLICE (km)</td>
<td>0.11</td>
<td>3.97</td>
<td>1.17</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>NETQUALITY</td>
<td>-56</td>
<td>70</td>
<td>14</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>DAYTIME</td>
<td>Yes = 19 (9%), No = 196 (91%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEEKDAY</td>
<td>Yes = 35 (16%), No = 180 (84%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risky</td>
<td>VIOLENTCRIME</td>
<td>0</td>
<td>1,017</td>
<td>408</td>
<td>197</td>
</tr>
<tr>
<td>NEGATIVE (km)</td>
<td>&lt;.01</td>
<td>1.84</td>
<td>0.17</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>ACTIVITIES (km)</td>
<td>&lt;.01</td>
<td>1.86</td>
<td>0.34</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>POLICE (km)</td>
<td>0.01</td>
<td>4.93</td>
<td>1.09</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>NETQUALITY</td>
<td>32</td>
<td>70</td>
<td>12</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>DAYTIME</td>
<td>Yes=70 (33%), No = 145 (67%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEEKDAY</td>
<td>Yes=61 (28%), No = 154 (72%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Results of Tobit Regression of Substance Use with Ecological Characteristics 
(N=215)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Model 1: Home Place</th>
<th>Model 2: Safe Place</th>
<th>Model 3: Risky Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIOLENTCRIME</td>
<td>-0.02 (-1.25)</td>
<td>-0.01 (-0.81)</td>
<td>0.01 (1.26)</td>
</tr>
<tr>
<td>NEGATIVE</td>
<td>-20.40 (-1.19)</td>
<td>-27.02 (-1.70)</td>
<td>-27.57 (-2.01)*</td>
</tr>
<tr>
<td>ACTIVITIES</td>
<td>-38.66 (-2.73)**</td>
<td>-9.63 (-0.83)</td>
<td>-3.21 (-0.39)</td>
</tr>
<tr>
<td>POLICE</td>
<td>2.69 (0.66)</td>
<td>3.56 (0.91)</td>
<td>9.32 (2.5)*</td>
</tr>
<tr>
<td>DAYTIME</td>
<td></td>
<td>1.41 (0.19)</td>
<td>-10.60 (-2.38)*</td>
</tr>
<tr>
<td>WEEKDAY</td>
<td></td>
<td>-13.23 (-2.17)*</td>
<td>-9.32 (-1.89)</td>
</tr>
<tr>
<td>HOMESAFE</td>
<td>-0.41 (-0.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>31.69 (2.72)**</td>
<td>21.78 (2.25)*</td>
<td>6.57 ()</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-666.20</td>
<td>-666.85</td>
<td>-660.30</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>10.43</td>
<td>9.14</td>
<td>22.24***</td>
</tr>
</tbody>
</table>

Coefficients are reported with t-statistics in parentheses. 
*p<0.05, **p<0.01, ***p<0.005
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES (home place)</td>
<td>-36.73 (-2.73)**</td>
<td>-24.60 (-2.05)*</td>
<td>-21.74 (-1.96)*</td>
</tr>
<tr>
<td>WEEKDAY (safe place)</td>
<td>-9.84 (-1.72)</td>
<td>-9.35 (-1.83)</td>
<td>-3.84 (-0.80)</td>
</tr>
<tr>
<td>NEGATIVE (risky place)</td>
<td>-37.86 (-2.92)***</td>
<td>-34.50 (-3.01)***</td>
<td>-22.02 (-2.06)*</td>
</tr>
<tr>
<td>POLICE (risky place)</td>
<td>8.36 (2.46)*</td>
<td>6.74 (2.22)*</td>
<td>4.34 (1.53)</td>
</tr>
<tr>
<td>DAYTIME (risky place)</td>
<td>-9.79 (-2.21)*</td>
<td>-6.71 (-1.70)</td>
<td>-3.68 (-0.99)</td>
</tr>
<tr>
<td>NETQUALITY (risky place)</td>
<td></td>
<td>-0.76 (-6.43)***</td>
<td>-0.56 (-4.91)***</td>
</tr>
<tr>
<td>MALE</td>
<td></td>
<td></td>
<td>10.16 (2.88)***</td>
</tr>
<tr>
<td>AGE</td>
<td></td>
<td></td>
<td>4.39 (5.01)***</td>
</tr>
<tr>
<td>Constant</td>
<td>24.68 (4.26)***</td>
<td>29.86 (5.69)***</td>
<td>-51.74 (-3.14)</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-658.39</td>
<td>-636.46</td>
<td>-621.97</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>26.07***</td>
<td>69.92***</td>
<td>98.90***</td>
</tr>
</tbody>
</table>

Coefficients are reported with t-statistics in parentheses.
*p<0.05, **p<0.01, ***p<0.005
Table 5. Results of Tobit regression of substance use for sub-groups based on sex and age.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Model 1 (N=79)</th>
<th>Model 2 (N=59)</th>
<th>Model 3 (N=41)</th>
<th>Model 4 (N=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES (home place)</td>
<td>-19.29 (-1.17)</td>
<td>-69.49 (-1.67)</td>
<td>-41.65 (-3.03)***</td>
<td>-6.10 (-0.14)</td>
</tr>
<tr>
<td>WEEKDAY (safe place)</td>
<td>-21.73 (-2.95)***</td>
<td>5.92 (0.53)</td>
<td>9.13 (1.25)</td>
<td>-31.45 (-1.5)</td>
</tr>
<tr>
<td>NEGATIVE (risky place)</td>
<td>-50.55 (-3.21)***</td>
<td>-12.04 (-0.38)</td>
<td>8.76 (0.45)</td>
<td>19.04 (0.40)</td>
</tr>
<tr>
<td>POLICE (risky place)</td>
<td>10.16 (2.33)*</td>
<td>-0.12 (-0.01)</td>
<td>3.70 (1.09)</td>
<td>-3.74 (-0.37)</td>
</tr>
<tr>
<td>DAYTIME (risky place)</td>
<td>2.15 (0.40)</td>
<td>-3.32 (-0.31)</td>
<td>-3.60 (-0.66)</td>
<td>-24.43 (-1.82)</td>
</tr>
<tr>
<td>NETQUALITY (risky place)</td>
<td>-0.60 (-3.63)***</td>
<td>-1.18 (-2.74)**</td>
<td>-0.42 (-2.49)*</td>
<td>-0.41 (-1.05)</td>
</tr>
<tr>
<td>Constant</td>
<td>28.75 (3.55)***</td>
<td>29.91 ()</td>
<td>39.35 (6.48)***</td>
<td>24.32 (1.41)</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-251.66</td>
<td>-107.32</td>
<td>-153.52</td>
<td>-89.29</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>30.46***</td>
<td>18.64***</td>
<td>18.86***</td>
<td>8.23</td>
</tr>
</tbody>
</table>

Coefficients are reported with t-statistics in parentheses.
*p<0.05, **p<0.01, ***p<0.005
List of Figures

Figure 1. Conceptual framework for modeling influences on adolescent substance use. Top diagram shows direct effects of individual and place-based ecological and social network characteristics on substance use. Bottom diagram shows effects of place-based ecological and social network characteristics on substance use as moderated by individual characteristics.

Figure 2. Data collection procedure for activity space and place-based social network quality data (Mason et al., 2009)

Figure 3. Geographic features associated with commercial zones in West Philadelphia, proximity to which is theorized to enhance adolescent substance use.

Figure 4. Geographic features in West Philadelphia that provide recreational activities for adolescents, and which are therefore theorized to suppress adolescent substance use.
Ecological

Social

Individual

Activity Space

Substance Use

Moderates

Ecological

Social

Individual

Activity Space

Substance Use
1. Adolescent Social Network Assessment
   a. Generate list of each adolescents’ close personal contacts, their strong ties which constitute their social networks (up to five network members)
   b. Collect behavioral information on each person in their social network
   c. Create a social network quality score for each person based upon:

   **Risk values**
   - Substance user = -1
   - Daily user = -3
   - Risky activities = -4
   - Influence to use = -6

   **Protective values**
   - Non-user = 4
   - No risk activities = 4
   - Influence not to use = 6

   Total network quality scores range from -14 to 14

2. Ecological Interview
   a. Free listing of home and routine locations
   b. Identification of places as: Home, Safe, or Risky
   c. Linking social network members to places:
      “Who in your network typically is with you at your Important, Safe, Risky, Favorite, and Home place?”

3. Place-Based Social Network Quality
   a. Each subject has a social network quality score calculated on the members’ risk and protective values who are typically at each identified place with the subject
   b. Total place-based network scores can range from -70 to 70 (5x-14, 5x14)