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# The spatial and temporal association of neighborhood drug markets and rates of sexually transmitted infections in an urban setting

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## ABSTRACT

This study examined temporal and spatial relationships between neighborhood drug markets and gonorrhea among census block groups from 2002 to 2005. This was a spatial, longitudinal ecologic study. Poisson regression was used with adjustment in final models for socioeconomic status, residential stability and vacant housing. Increased drug market arrests were significantly associated with a 11% increase gonorrhea (adjusted relative risk (ARR) 1.11; 95% CI 1.05, 1.16). Increased drug market arrests in adjacent neighborhoods were significantly associated with a 27% increase in gonorrhea (ARR 1.27; 95% CI 1.16, 1.36), independent of focal neighborhood drug markets. Increased drug market arrests in the previous year in focal neighborhoods were not associated with gonorrhea (ARR 1.04; 95% CI 0.98, 1.10), adjusting for focal and adjacent drug markets. While the temporal was not supported, our findings support an associative link between drug markets and gonorrhea. The findings suggest that drug markets and their associated sexual networks may extend beyond local neighborhood boundaries indicating the importance of including spatial lags in regression models investigating these associations.

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## 1. Introduction

Investigations into the dynamics of STI transmission over the past 30 years have demonstrated that a small group of individuals, called core transmitters, tend to drive STI rates in a population (Yorke et al., 1978; Thomas and Tucker, 1996; Brunham, 1991). Core transmitters maintain and fuel disease rates in the population by repeatedly acquiring and transmitting disease (Ellen et al., 1997). Early definitions of core groups relied largely on information about numbers of sex partners; however, more recent theory and evidence supports defining core groups using information about the sexual network connections among core group members (Potterat et al., 1985; Brunham, 1991; Watts and May, 1992; Kretzschmar and Morris, 1996; Ghani et al., 1997; Morris and Kretzschmar, 1997; Potterat et al., 1999; Koumans et al., 2001; Newman, 2002; Jolly and Wylie, 2002; Cunningham et al., 2004). Empirical investigations of disease transmission networks, along with mathematical models, have confirmed the importance of interconnected network structures for the maintenance of

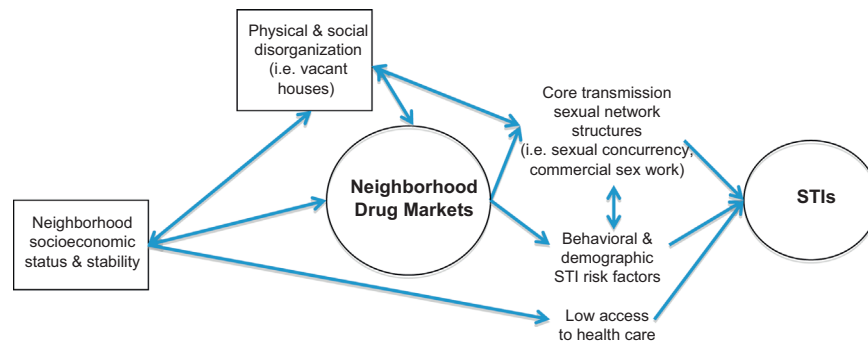
endemic disease, including gonorrhea and HIV (Brunham, 1991). Highly interconnected sexual networks, however, may be necessary but not sufficient to explain core group transmission. Studies have found variability in disease transmission networks within similarly characterized networks (Wylie et al., 2010).

Variability in disease transmission networks may in part be due to place differences. That is, network structures bounded in specific geographic locations may be critical for active and ongoing transmission (Weir et al., 2003; Jennings et al., 2005; Diez Roux, 2007; Wylie et al., 2010; Fichtenberg et al., 2010). The importance of network structures in place is supported by extensive evidence that rates and counts of STIs are heterogeneous across city or county geographies (Rothenberg, 1983; Lacey et al., 1997; Jennings et al., 2005; Monteiro et al., 2005; Risley et al., 2007; Schleihau et al., 2009). Additional studies have shown that important transmission behaviors such as sexual concurrency (overlapping sexual partnerships in time) or high numbers of sex partners do not predict STIs alone; rather the relationship of these behaviors to STI transmission is affected by the prevalence of STIs in the local area (Serwadda et al., 1992; Jennings et al., 2004).

A conceptual framework is presented in Fig. 1. It sets the dynamics investigated here within a broader outline of how neighborhood drug markets may link to other neighborhood factors setting up the likelihood for the transmission and persistence of STIs. Our hypotheses are based on the central idea that

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Adapted from Jennings et al. 2012 and Farley 2006.

Note: Encircled elements are of primary interest and are tested in this manuscript, i.e. the relationship between neighborhood drug markets and STIs. Elements in squares are controlled for and other elements are hypothesized to play a role but are not directly tested here.

**Fig. 1.** Orienting framework showing the hypothesized relationship between neighborhood drug markets and sexually transmitted infections (STIs) along with other variables of interest.

Note: Encircled elements are of primary interest and are tested in this manuscript, i.e. the relationship between neighborhood drug markets and STIs. Elements in squares are controlled for and other elements are hypothesized to play a role but are not directly tested here.

Source: Adapted from Jennings et al. (2012) and Farley (2006).

within and around drug markets, multiple complex social phenomena are occurring which result in increased STI transmission. Within drug market social networks, individuals may meet sexual partners and may have overlapping sexual partnerships in time (sexual concurrency) (Ellen et al., 1997). Commercial sex work and the exchange of sex for drugs or money may create networks where a few individuals have large numbers of sexual partners. Commercial sex work and sexual concurrency have been associated with risk for both heterosexual and homosexual transmission of HIV (Flom et al., 2001; Adimora et al., 2007; Gyarmath and Neaigus 2009; Fast et al., 2010). Sexual activity may not occur physically at the geographical location of the drug market, but sexual networks may occur as a result of connections formed within the drug market social network. There is considerable evidence that individuals engaged in drug dealing or use have high rates of HIV and other STIs including gonorrhea (Friedman et al., 2005; Centers for Disease Control and Prevention, 2009).

Our recent work suggests that specific places are associated with risks for STIs independent of individual STI risk factors. In a multilevel, cross-sectional household study among youth in an urban setting, we demonstrated that places with neighborhood drug markets were associated with an increased likelihood of selecting a high-risk sexual partner and, separately, of current infection with a bacterial STI *at the individual level* (Jennings et al., 2012). Neighborhood drug markets are defined as specific geographic areas where illicit drug dealing (e.g., heroin, cocaine including crack-cocaine, and/or marijuana) occurs (Reuter and MacCoun, 1992). Our findings supported our hypothesis that neighborhood drug markets have the necessary and sufficient factors to maintain disease transmission, namely disease prevalence and highly interconnected network structures. This premise is further supported by other work that has found drug dealers and users have high STI prevalence (Thomas and Tucker, 1996). The strengths of our study were that it extended previous ecologic analyses and used multilevel (neighborhood and individual level) information to deduce the independent effect of place. The study, however, was cross-sectional in design and, thus, we could not conclude a causal effect between neighborhood drug markets and risk for an STI. Furthermore, the study treated neighborhoods as independent units of analyses, which belies the spatial nature of networks and specifically the likely fluidity of networks between adjacent neighborhoods.

In the current study, we built on our previous work and addressed the limitations of causality and spatial effects using spatial and longitudinal ecologic analyses. The objectives of the current study were to (1) investigate whether increased neighborhood drug market activity was associated with increased gonorrhea occurrence in the same neighborhood using ecologic analyses, (2) investigate whether increased neighborhood drug market activity in surrounding or adjacent neighborhoods was associated with increased gonorrhea occurrence in the focal neighborhood using spatial ecologic analyses, and (3) determine whether the presence of drug markets in the previous year is predictive of gonorrhea occurrence in the subsequent year.

## 2. Methods

### 2.1. Setting

The study was conducted in Baltimore City, Maryland, a city with a long history of syndemic illicit drug activity and STI infection. Baltimore is located in the Mid-Atlantic United States (U.S.) and had a 2010 population of 620,961 (US Census Bureau, 2011). Baltimore has endemic rates of injection drug-use (IDU) and non-IDU (Gleghorn et al., 1995; Simon and Burns, 1997; Agar and Reisinger, 1999; Nandi et al., 2010; Mehta et al., 2006). The actual numbers of illicit drug users are difficult to calculate, but estimates suggest that in 2002 Baltimore City had 20,120 IDUs, with heroin featuring prominently (United States National Drug Intelligence Center, 2003). Police suggest that illicit drugs are a factor in eight of every ten homicides in the city (Craig, 2000). Baltimore also has endemic rates of STIs, and is a city with severe racial/ethnic disparities in STIs (Centers for Disease Control and Prevention, 2011). In 2010, Baltimore had the second highest gonorrhea rate per 100,000 population among U.S. counties (Centers for Disease Control and Prevention, 2011).

### 2.2. Data collection

This was a spatial, longitudinal ecologic study. Data on outcomes, exposures, demographics, and socioeconomic indicators were collected for the 710 census block groups (CBGs) in Baltimore City annually from 2002 to 2005 from multiple sources including the Baltimore City Health Department, Baltimore City Police

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