HIV TRANSMISSION RISKS AMONG WOMEN IN ONE MID-ATLANTIC U.S. CITY

by

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Abstract

In 2012 in Baltimore City, more than one third of reported HIV diagnoses among women were associated with a high-risk heterosexual contact (HET) and approximately half were not associated with any reported exposure (NRR); the remaining diagnoses were associated with injection drug use (IDU) transmission risk. There is limited information on the differences between women who acquire HIV via known heterosexual exposure versus women who report no exposure risk. The objective of this study was to determine the extent to which women classified as having high-risk heterosexual contact (HET) or injection drug use (IDU) transmission risk were similar to or different from women without a defined exposure category (NRR). The study population included women newly diagnosed with HIV as reported to the Baltimore City Health Department (BCHD) between January 2009 and June 2014 with complete interview records and a valid address within Baltimore city (n=357). We examined the distribution of demographic characteristics, substance and sexual risk behaviors and neighborhood-level factors associated with classification of NRR versus HET/IDU/CSW using t-tests, Chi-square tests and Fisher's exact tests, as appropriate. Reported addresses were geocoded, mapped and tested for hot spots in order to determine if there was geographic clustering of diagnoses by exposure category. Overall, both classification categories appeared to have similar distributions of demographic, risk behaviors and neighborhood characteristics. There did not appear to be different patterns of geographic distribution by exposure category. Women who are classified as NRR appear similar to those who report risk factors that lead to classification as HET/IDU/CSW. As exposure categories reveal

salient information about epidemic characteristics, more research should be undertaken to understand heterosexual transmission in this population.

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I. Introduction

Baltimore, Maryland, has one of the most severe HIV epidemics in the nation. The metropolitan statistical area (MSA) containing Baltimore city reported an HIV prevalence of 664.1 HIV infections per 100,000 residents in 2012, placing it in the top five MSAs in the United States with the highest prevalence of HIV infections.[1] Approximately 2.3% of the population of Baltimore city is infected with HIV, 37.5% of those infections are women.[2] Exposure categories include men who have sex with men (MSM), injection drug users (IDU), MSM/IDU and heterosexual contact; among the latter category of heterosexual exposure women make up 67% of the category in Baltimore city similar to the rest of the nation.[1,2]

In 2012 in Baltimore city, 36% of reported HIV diagnoses among women were associated with a high-risk heterosexual contact, which is defined as a sexual partner known to have HIV, or a sexual partner at high risk of HIV—men who have sex with men (MSM) or an injection drug user (IDU).[2] Twelve point five percent of reported diagnoses among women were associated with injection drug use and 50.7% were not associated with any reported exposure.[2]

Newly diagnosed women who report high-risk heterosexual contact but not injection drug use are classified in the heterosexual exposure category (HET) while women who report injection drug use, regardless of other reported behaviors, are classified in the injection drug user exposure category (IDU). Those with no exposure information are classified as 'other'—for the purpose of this analysis they will be classified as having no reported risk (NRR).[3]

As exposure categories reveal salient information about epidemic characteristics, it is important for researchers and public health officials to understand who these categories encompass to best tailor research and public health priorities. The fact that there is limited to no information about the route of infection for so many women may suggest the existence of a relevant subgroup within the heterosexual exposure category—be it women who are in riskier environments or with higher levels of certain behaviors or women who do not realize they are at risk. This has important implications for the reach and scope of efforts designed to reduce HIV transmission.

The objective of this study was to determine the extent to which women classified as having high-risk heterosexual contact (HET) or injection drug use (IDU) transmission risk were similar to or different from women without a defined exposure category (NRR) among newly HIV diagnosed women in Baltimore city from January, 2009 to June, 2014. Given the established syndemics of HIV and IDU in Baltimore city and the long history of a concentrated heterosexual epidemic in this urban area as in other U.S. urban areas, we hypothesized that women in the two classification categories would look very similar to one another.[4,5] We compared the women on characteristics including individual demographics, sexual and drug risk behaviors, history of STIs, test provider and place-based neighborhood characteristics.

Better characterizing this population could potentially reveal important information about the heterosexual HIV epidemic in Baltimore. Several explanations for this inability to report information leading to a definitive exposure category assignment are possible—all of which have potential implications for public health measures

targeting this population. First, women who do and do not report risk factors that allow for heterosexual contact exposure category classification are the same population, but a random proportion of women accurately ascertained sex partner serostatus and relevant risk behaviors and the remainder did not. An alternative explanation is that in certain parts of the United States, HIV is being transmitted heterosexually to women by heterosexual men who are neither MSM nor IDU—meaning the epidemic has become generalized in these populations. In a generalized epidemic, HIV transmission occurs widely in the heterosexual population between individuals without traditionally high-risk behaviors such as IDU or MSM.

II. Background

Knowledge of heterosexual transmission dynamics in the United States is limited. Although high-risk heterosexual contact is estimated to lead to 25% of all newly diagnosed HIV infections—and an estimated 87% of newly diagnosed infections among women—factors associated with increased risk of heterosexual acquisition have been understudied.[1,6] The HIV epidemic in the United States is thought to be a primarily concentrated epidemic—that is, one in which most infections occur within core high-risk groups: injection drug users (IDU), men having sexual contact with other men (MSM), and the partners of these individuals.[1] Many heterosexual cases are thought to originate from individuals who have partners in one of these high-risk groups and exist within a sexual network with a core group of these partners.[7]

Unlike determining MSM and IDU exposure categories, the heterosexual exposure category is unique in that it solely depends on the risk factors of the partner,

rather than individual risk behaviors. While heterosexual HIV transmission occurs via unprotected vaginal or anal sex, these behaviors are not sufficient to adequately define the heterosexual female population at increased risk of HIV in the United States. Rather, a complex web of demographic, behavioral, place, network and structural factors are thought to contribute to risk of HIV acquisition in heterosexual women.

Meta-analyses have demonstrated that the per-act and per-partner risk of acquiring HIV heterosexually can vary substantially based on certain cofactors.[8,9] Moreover, locating individuals at increased risk of heterosexual transmission depends on much more than behavioral characteristics. Indeed, the latest heterosexual cycle of the National HIV Behavioral Surveillance System (NHBS-HET) conducted recruitment among low socioeconomic status individuals living high-prevalence areas.[10]

As such, defining and finding the population of women at increased risk of HIV acquisition in the United States has proved to be a difficult task as a shifting calculus of place-based, demographic, behavioral and partner characteristics must be known in order to attempt to assess HIV acquisition risk.

Place-based characteristics: One of the most notable factors identified when defining risk of HIV acquisition among heterosexual women is location of residence. HIV is not evenly distributed throughout the United States—rather, high prevalence of HIV is concentrated in certain areas, particularly urban centers.[1] Uneven HIV prevalence by geographic location creates differential likelihoods that women with the same sexual risk behaviors may come in contact with a sexual partner with HIV. Additionally, more

localized place-based characteristics may lead to increased risk of HIV among women. In the United States, these risk factors may include living in poverty-stricken neighborhoods, neighborhoods with high levels of social disorder, low social cohesion, areas with high levels of drug use, and high levels of incarceration.[11,12] Studies have linked sexual risk behaviors and risk of HIV acquisition and STIs more broadly to these characteristics by looking at how markers of deprivation and social disorder influence health outcomes and sexual network characteristics.[13,14] Entrenched neighborhood poverty and social disorder have been demonstrated to be associated with sexual network structural characteristics that facilitate HIV transmission.[15,16]

Network characteristics: Sexual network composition and structure is another critically important consideration when assessing risk of heterosexual HIV risk.[17] Sexual networks that contain a small number of individuals with many sexual contacts may create efficient pathways through which disease can be transmitted. These individuals form the 'core group' of a network, which facilitate the spread to disease to individuals within the network who may not have individual-level behavioral risks.[18] These network characteristics are in part captured by measures of sexual concurrency (defined as overlapping sexual partnerships where sexual intercourse with one partner occurs between two or more acts of intercourse with another partner) and individuals with high numbers of sex partners.[19]

Network characteristics, however, may be necessary but not sufficient to explain the properties of actively transmitting networks. Studies have found variability in disease

transmission networks within similarly characterized networks.[20] In part this may be because it is not these characteristics alone that allow for active transmission; rather it is the combination and interaction of these characteristics brought together in space and time that may create unique network structures which allow for active transmission.[21] The importance of the unique network structures is highlighted by the fact that neither sexual concurrency nor high numbers of sex partners alone predict HIV infection in the general population residing in high prevalence communities.

Individual behaviors and characteristics: Individual-level factors must also be considered when conceptualizing risk of HIV acquisition in heterosexual women. The intersection of structural, place-based and sexual network factors on individual-level risk among heterosexual women is most clearly illustrated in the dramatic racial disparities in HIV incidence and prevalence. Non-Hispanic black women make up a disproportionate share of HIV-positive women in the United States.[1] This disparity is likely influenced by the concentration of structural inequalities experienced by the non-Hispanic black population in the United States.[22,23] The disparity in HIV rates may also be reinforced by the disparity in STI rates—which are known to be associated with risk of HIV acquisition. Bacterial and viral STIs other than HIV are much more prevalent among black Americans than white Americans.[14]

Additionally, a number of the variables discussed in relation to neighborhood-level risk factors are closely related with individual-level risk factors. Socioeconomic status is one such example. Individuals living in poverty may have less access to health

care and interact less with the health system, which might lead to both less knowledge and evaluation of other HIV risk factors and—as individuals living in poverty tend to be clustered in geographic areas—might increase the proportion of HIV-positive individuals in the community not receiving anti-retroviral therapy or unaware of their HIV-positive status—thereby contributing to the likelihood that they will transmit HIV to other sexual contacts.[24,25] Poverty may also go hand-in-hand with certain other characteristics known to be associated with risk of HIV infection, such as low educational attainment, homelessness and food insecurity. Homelessness has also been found to be associated with increased HIV risk.[26] Individual level of education has also been found to be associated with risk of HIV acquisition or risk behaviors in heterosexual women. However, as low education and poverty status are highly linked, it is unclear whether education status may contribute to HIV risk through the same route as poverty or some other means.[24,27]

One risk behavior associated with both poverty and risk of HIV acquisition among heterosexual women is participation in exchange sex. For instance, one study found that having experienced food insecurity in the past six months was significantly associated with being more likely to engage in exchange sex and unprotected anal intercourse.[27]

Participation in exchange sex is not only linked to poverty but also to drug use— both injection and non-injection.[28,29] Drug use has also been long linked with risk of HIV infection. While injection drug use—including heroin, methamphetamine and crack cocaine—presents parenteral risks, drug use and addiction may facilitate other risk

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behaviors such as unprotected intercourse that increase risk of becoming infected with HIV.[30] Through the same mechanism of decreased ability to adequately assess risk, alcohol consumption has also been linked to transmission of HIV.[31]

While number of sexual partners does impact HIV risk, it does not impact all groups equally—differing in different contexts and among different groups.[32] In particular, number of partners may contribute to increasing risk within in the context of particular sexual networks. If network HIV prevalence is very low, having a large number of sexual partners could be less risky than having only one partner in a network where HIV prevalence is very high. Concurrency and network position seems to be more important than the number of partners.

III. Data and Methods

Study population: The study population included newly HIV diagnosed women reported to the Baltimore City Health Department (BCHD) between January, 2009 and June, 2014 (n=618). Under Maryland law, all HIV infections diagnosed by providers in Baltimore must be reported to the health department in a timely manner. Surveillance data for newly reported HIV data is derived from provider-submitted morbidity reports, a BCHD-developed intake form (which is not required to be administered by all providers) and from follow-up interviews with newly diagnosed patients conducted by BCHD. Risk factor information reported from any of these data sources is used to assign exposure category. However, the ability of these different methods to elicit responses of risk factor data differs. For instance, BCHD intake form data was only available for 30.4% (n=188) of new diagnoses reported, due to most private and hospital providers not using these

forms. Additionally, as not all patients consent to be interviewed post-diagnosis or cannot be located to be interviewed, 40.1% (n=248) of diagnoses did not have an interview record. Of the 618 reported cases, all had an associated morbidity report; 11.2% (n=69) had additional data only from intake forms; 40.6% (n=251) only from interview records; 19.3% (n=119) from both interview records and intake forms; and 29.0% (n=179) from neither. As the purpose of this analysis was to compare women who specifically did not report HET or IDU to those who did, those who were classified as NRR were excluded from the analysis if they were only classified as NRR due to missing information (n=179). Additionally, cross-tabulations revealed that women were far less likely to report risk factors on the intake form that led to classification as HET or IDU than they were in BCHD-initiated interviews. In order to ensure consistency of risk reporting, records associated with only intake data were excluded from the analysis (n=69). Finally, as the analysis focused on residents of Baltimore city, all records not associated with a valid, geocodable address located in Baltimore city were excluded (n=13). The final analysis set consisted of 357 new HIV diagnoses among women with an interview record and a valid address in Baltimore city (see Figure 1). Individual and neighborhood

Figure 1. Inclusion and exclusion criteria for women in Baltimore city newly diagnosed with HIV between January 2009 and June 2014.
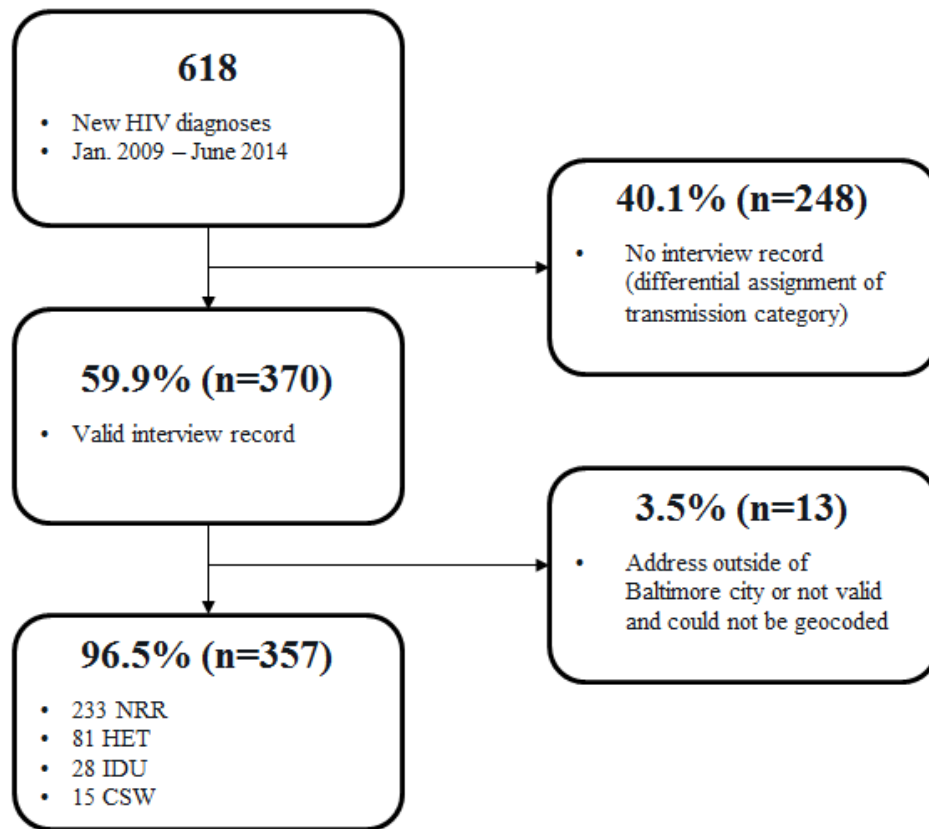
bivariate associations were examined using t-tests, Fisher's exact test and Chi-square tests.

This study was approved under the umbrella of the Category C: Identifying High HIV Transmission Areas in Baltimore City project approved by the Johns Hopkins Medicine Institutional Review Boards.

Measures: Individual-level information including demographics, sexual and drug risk information as well as lifetime history of bacterial STIs was obtained from morbidity reports, BCHD interview and BCHD intake data.

Individual level

Exposure categories: Exposure categories used by the CDC were assigned according to risk factors reported by new diagnoses who had been interviewed.[3] Women were classified as having a defined exposure category if they reported sex with an HIV-positive person or sex with a person known to be at high risk of HIV—an injection drug user or a man who also had sexual contact with men (HET) or if they reported injection drug use (IDU). Additionally, as commercial sex work (CSW) is highly linked with injection drug use and the HIV epidemic in Baltimore city, women who reported CSW but not IDU or HET (n=15) were classified as having a known exposure category for the purpose of the primary analysis.[33] In total, 35.7% of the new diagnoses included in this analysis were classified as having a known exposure category—grouped together as

HET/IDU/CSW. Women who did not report any of the behaviors described above were classified as NRR—no risk reported (n=233).

Age: Age at time of diagnosis was examined continuously and categorically.

Race/ethnicity: The vast majority of diagnoses were among non-Hispanic black women, with very few cases associated with races other than non-Hispanic black or white, or with Hispanic ethnicity. Therefore, race was coded as non-Hispanic black, non-Hispanic white and other, with women reporting other races or Hispanic ethnicity included in the other category.

Educational level: Education level was coded as having less than a high school education, having a high school degree or equivalent, or having more education than high school. This information was only available for a small subset of the study population (n=54) because this information was collected only by intake form and many women refused to provide an answer.

Marital status: Marital status was coded as currently being married or being in a committed relationship or being never married or not in a current committed relationship. This information was only obtained on a subset of the study population (n=114) because this information was collected only by intake form.

Number of sex partners: Women were asked to report the number of sex partners in the twelve months prior to HIV diagnosis. Patients were classified as reporting more than one sex partner or one partner or fewer in the past twelve months.

Bacterial sexually transmitted infection (STI) co-infection and history: Bacterial STI co-infections are thought to increase risk of HIV acquisition.[34,35] Data for other STI

testing at the time of HIV diagnosis was not available and it can be surmised from the distribution of provider types that many of the women did not receive testing for other STIs at the time of their HIV diagnosis. Therefore, STI co-infections were not included in the final analysis because the number of identified co-infections was too low to be an accurate representation of infection. Rates of bacterial STIs in Baltimore city in 2013 ranged from 1,247 cases per 100,000 for chlamydia and 346.6 cases per 100,000 for gonorrhea—given these rates are higher for the reproductive-aged population, the number of identified co-infections was a clear underreporting.[36,37] As syphilis, gonorrhea and chlamydia are reportable conditions in Maryland, lifetime history of these infections was assessed by past provider report of a positive diagnosis of any of these conditions to the BCHD.

Substance use: Additionally, 34% of women had complete data on substance use (n=113). Substance use was classified by self-report of having used alcohol, cocaine or marijuana in the past twelve months.

Provider type: As HIV testing behavior is known to differ by perception of risk factors and/or the presence of symptoms,[38,39] provider type at first diagnosis was analyzed. All HIV diagnosis reports include provider information. Provider types were classified into broad categories: BCHD-led outreach; other HIV testing outreach efforts; BCHD-run STI clinics; emergency departments; other health care providers; and unknown/other provider types. Baltimore City Health Department conducts mobile outreach in neighborhoods known to have high HIV and syphilis rates. Other outreach efforts include testing outreach led by community-based organizations. Other health care

providers include private practitioners, community health clinics as well as outpatient and inpatient hospital care.

Neighborhood level

Population: Census tract population was assessed by constructing tertiles of the total census tract population.

Poverty: Census tract level poverty was assessed by constructing tertiles of the percent of census tract residents living at 100% of below of the federal poverty line.

Male to female ratio: Sex ratios were calculated as the proportion of men age 15-64 to women ages 15-64 obtained from the ACS estimates. Census tracts with low sex ratios were determined by using a cutoff of 90 men ages 15-64 to 100 women ages 15-64. Normal census tract sex ratios ranged from 95–105 males to 100 females. Women living in census tracts with sex ratios falling outside of these categories were excluded from this portion of the analysis.

Employment: Census tract employment rates were measured by estimating the percent of adult residents in the neighborhood currently employed. Employment rates were categorized into tertiles.

Vacancy: Census tract measurements of percent of vacant dwellings were obtained from the ACS estimates. Vacancy rates were categorized into tertiles.

Statistical Analysis

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Comparisons of individual level and neighborhood level characteristics between newly HIV diagnosed women classified as NRR versus HET/IDU/CSW were conducted using t-tests, Chi-square tests and Fisher's exact tests as appropriate.

Geographic Analysis

All morbidity reports included the address provided by the patient. These addresses were geocoded using ArcGIS 10.2.2. Geocoded addresses were then associated with the U.S. census tract the address fell inside. Census tracts were used as a proxy for neighborhoods.[40] Characteristics associated with census tracts were analyzed to determine characteristics of neighborhood associated with exposure categories. All census tract information (e.g. poverty, male to female ratio, employment, vacancy) was obtained from the 2009–2013 American Community Survey.[41]

Ninety-six point five percent of eligible study participants were able to be geocoded to a census tract. Women with geocodable addresses (n=357) compared to women without geocodable addresses (n=13) were not statistically different on demographic and sexual risk and drug-related characteristics, but were more likely to be classified as NRR.

Counts per census tract of all diagnoses, diagnoses classified as NRR, and diagnoses classified as HET/IDU/CSW were mapped in order to visually examine the geographic spread of the diagnoses by exposure category. Additionally, a hot spot analysis using the Getis-Ord Gi* statistic in ArcGIS 10.2.2 was conducted separately for

all diagnoses, NRR diagnoses and HET/IDU/CSW diagnoses to visually examine if hot spots for different exposure categories were similar or different.

Sensitivity Analysis

A sensitivity analysis was conducted to test the grouping of HET/IDU/CSW in which NRR were compared to only HET women, with both IDU and CSW excluded.

IV. Results

Overall, 65.3% (n=233) of women were determined to be NRR and 34.7% (n=124) were classified as HET/IDU/CSW (Table 1). Age distributions were similar: mean age for NRR was 38.4 (SD 12.4) and mean age for HET/IDU/CSW was 38.9 (SD 12.2). Racial makeup reflected what is known about the HIV epidemic among women in Baltimore, which is that non-Hispanic black women are overrepresented. Of NRR category, 92.7% identified as non-Hispanic black (n=216). This was found to be significantly different from the HET/IDU/CSW category, where 81.5% of women identified as non-Hispanic black, 12.9% identified as non-Hispanic white and 5.7% as another race or ethnicity.

Marital status and level of education was assessed by intake forms, of which only 31.9% of women in this sample completed (n=114). Most women reported being never married or currently single. A little more than half of the women who completed intake forms refused to provide their level of education (n=60). Of those who replied, 32.3% of those in the NRR had not completed high school compared to 56.5% of those in the HET/IDU/CSW group.

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Number of sex partners was similar for both groups. For women in the NRR group, 65.3% reported one or no sex partners in the past twelve months; compared to 64.3% for those in the HET/IDU/CSW category. Additionally, 34.7% of those in the NRR group and 35.7% in the HET/IDU/CSW group reported two or more sex partners in the past twelve months.

Table 1. Demographic characteristics, substance use and sexual risk factors and census tract characteristics of women newly diagnosed with HIV in Baltimore city with an interview record and geocodable address between 2009 and 2014, by exposure category classification.

	NRR	HET/IDU/CSW	p
N=357	233 (65.3)	124 (34.7)	
Demographic Characteristics			
Age in years (mean)	38.4 (sd 12.4)	38.9 (sd 12.2)	0.700
<20 years	10 (4.3)	6 (4.8)	0.907
20-30 years	65 (27.9)	31 (25.0)	
30-40 years	39 (16.7)	26 (21.0)	
40-50 years	70 (30.0)	34 (27.4)	
50-60 years	42 (18.0)	22 (17.7)	
60+ years	7 (3.0)	5 (4.0)	
Non-Hispanic Black	216 (92.7)	101 (81.5)	**.003**
Non-Hispanic White	9 (3.9)	16 (12.9)	
Other Race/Ethnicity	8 (3.4)	7 (5.7)	
Not in committed relationship (n=114)	67 (95.7)	39 (88.6)	0.257
Committed relationship (n=114)	3 (4.3)	5 (11.4)	
Less than high school (n=54)	10 (32.3)	13 (56.5)	0.201
High school or GED (n=54)	14 (45.2)	7 (30.4)	
More than high school (n=54)	7 (22.9)	3 (13.0)	
Substance Use and Sexual Risk Factors			
Reported alcohol use (n = 104)	17 (21.5)	14 (28.6)	0.365
Reported cocaine use (n = 104)	7 (8.9)	11 (22.45)	0.032
Reported marijuana use (n = 104)	9 (11.4)	10 (20.4)	0.163
Reported sex and alcohol (n = 104)	10 (12.7)	6 (12.2)	0.945
Chlamydia history (yes)	53 (22.8)	30 (24.2)	0.758
Gonorrhea history (yes)	27 (11.6)	16 (12.9)	0.716
Syphilis history (yes)	16 (6.9)	9 (7.3)	0.890
Any bacterial STI history (yes)	73 (31.3)	39 (31.5)	0.981
Sex partners ≤1 (n=279)	109 (65.3)	72 (64.3)	0.866
Sex partners ≥2 (n=279)	58 (34.7)	40 (35.7)	
HIV Diagnosis Site			
BCHD Outreach	27 (11.6)	11 (8.9)	0.072
Emergency Departments	47 (20.2)	26 (21.0)	
BCHD Clinics	41 (17.6)	30 (24.2)	
Other Outreach	1 (0.4)	5 (4.0)	
Other Healthcare	102 (43.8)	47 (37.9)	
Unknown	15 (6.4)	5 (4.0)	

Table 1 (con.). Demographic characteristics, substance use and sexual risk factors and census tract characteristics of women newly diagnosed with HIV in Baltimore city with an interview record and geocodable address between 2009 and 2014, by exposure category classification.

Census Tract Characteristics			
	NRR	**HET/IDU/CSW**	**p**
Population Tertiles			0.470
Total population <2341	74 (31.8)	46 (37.1)	
Total population 2341 – 3515	82 (35.2)	44 (35.5)	
Total population >3515	77 (33.1)	34 (27.4)	
Poverty Tertiles			0.501
<24.6% ≤100% of FPL	82 (35.2)	37 (29.8)	
24.6% - 35.7% ≤100% of FPL	74 (31.8)	46 (37.1)	
>35.7% ≤100% of FPL	77 (33.1)	41 (33.1)	
Vacancy Tertiles			0.951
<17.8% of housing units vacant	79 (33.9)	40 (32.3)	
17.8% - 33.1% of housing units vacant	83 (35.6)	45 (36.3)	
>33.1% of housing units vacant	71 (30.5)	39 (31.5)	
Employment Tertiles			0.865
<41.7% of adults employed	80 (34.3)	46 (37.1)	
41.7% - 52% of adults employed	75 (31.2)	39 (31.5)	
>52% of adults employed	78 (33.5)	39 (31.5)	
Male-to-female sex ratio (n=158)			0.577
Low (<.90)	32 (13.7)	20 (16.1)	
Balanced (.95 – .105)	87 (37.3)	45 (36.3)	

Approximately a quarter of women in both categories were found to have a history of chlamydia: 22.8% for NRR and 24.2% for women in the HET/IDU/CSW group were found to have a history of chlamydia. Prevalence of gonorrhea history was slightly lower, but still significant with 11.6% of women in the NRR category and 12.9% of women in HET/IDU/CSW category having a history of gonorrhea infection. History of syphilis infection was 6.9% in women in NRR determined and 7.3% in the HET/IDU/CSW group. None of these differences was found to be significant. Overall, nearly identical proportions of both group had a history of at least one reported bacterial STI prior to HIV diagnosis: 31.3% for women without a determined exposure category and 31.5% for women in HET/IDU/CSW category.

Several variables had substantial amounts of missing data. However, missingness did not vary by exposure category assignment so the tabulations are presented here. Twenty-nine percent of women in the study provided information about alcohol or non-injection drug use (n=104). For alcohol use, 21.5% of the NRR group and 28.6% of the HET/IDU/CSW group reported alcohol use. Again, no significant difference was found in those that reported marijuana use, with 11.4% of NRR and 20.4% of HET/IDU/CSW reporting marijuana use. Positive reports of cocaine use did differ significantly: 8.9% of NRR reported cocaine use as compared to 22.5% of HET/IDU/CSW (p=0.032). This difference is linked to the inclusion of IDU and CSW in the latter category—in sensitivity analysis when IDU and CSW were excluded; no difference was found between the proportions of NRR versus HET who reported cocaine use.

There were some observed differences in provider types between the two exposure category classifications. Both NRR and HET/IDU/CSW women were most likely to be diagnosed at a healthcare provider other than a BCHD clinic or emergency department (43.8% and 37.9%). Approximately one in five in both categories was diagnosed at an emergency department (20.2% and 21.0%). BCHD outreach programs were the source of diagnosis for 11.6% of NRR and 8.9% of HET/IDU/CSW, while BCHD-run STI clinics were the site of diagnosis for 17.6% of NRR and 24.2% of HET/IDU/CSW. Small proportions of both groups were diagnosed in the course of non-BCHD HIV outreach efforts: 0.4% for NRR and 4.0% for HET/IDU/CSW.

In sensitivity analyses when IDU and CSW were fully excluded, different distribution of providers was seen. Those classified as HET were significantly more likely to be tested at the STI clinics run by BCHD (30.1% vs. 17.6%, p=0.03). This may be due to ascertainment bias—where women who know they may have been exposed to HIV (or another STI) sought out appropriate testing.
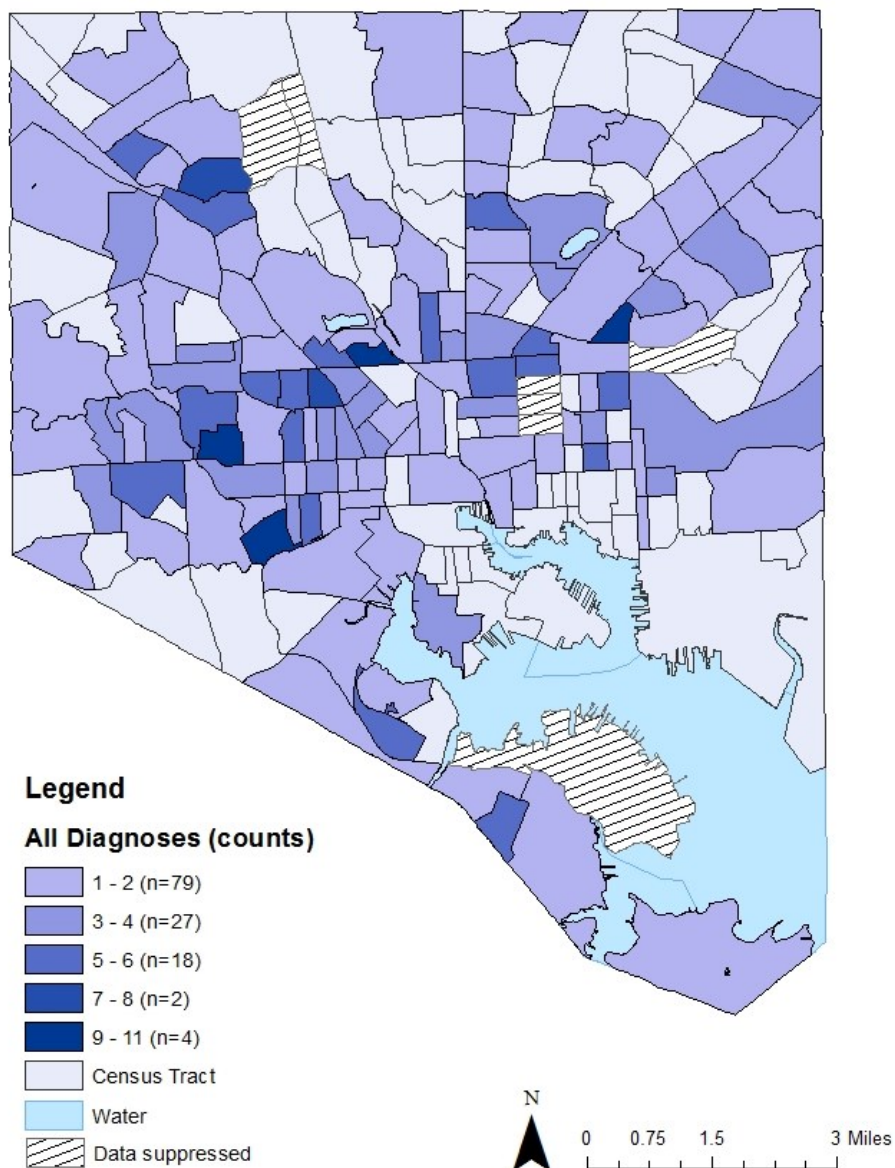
In addition to individual-level variables, census tract characteristics were compared between NRR and HET/IDU/CSW based on their reported residence (see Table 1). Both exposure category groups were very similar based on census tract characteristics. Women classified as NRR and HET/IDU/CSW were approximately evenly distribution across census tract population tertiles, although women classified as HET/IDU/CSW were somewhat more likely to live in census tracts with smaller populations, but this difference was not found to be significant. No significant differences were observed for tertiles of poverty, percent of vacant dwellings within the census tract,

or percent of the adult population of the census tract currently employed. No difference was found between NRR and HET/IDU/CSW comparing percent of each group living in a census tract with a low sex ratio compared to a normal sex ratio.

Mapping the census tracts of residence for study participants did not reveal any noticeable difference in geographic clustering of diagnoses for either NRR or HET/IDU/CSW. Diagnoses included in this analysis were reported in more than 60% (n=130) of census tracts in Baltimore City (n=120) (see Figure 2). The number of diagnoses per census tract ranged from one to 11. Geographic clustering was not observed for either NRR or HET/IDU/CSW diagnoses and there was substantial overlap between the two groups (see Figures 3 and 4). Of the 130 census tracts with at least one diagnosis, 90% contained at least one NRR diagnosis (n=117) and 58.5% contained at least one HET/IDU/CSW diagnosis (n=76). Of the 130 census tracts, 48.5% (n=63) contained at least one NRR diagnosis as well as at least one HET/IDU/CSW diagnosis.

Visual examination shows that the diagnoses for both exposure category groups are widely spread across the city with a particular concentration of diagnoses visible in the western section of the city, which is known to have a high prevalence of HIV infection.[2] Hot spot analysis with the Getis-Ord Gi* statistic indicated statistically significant concentrations of diagnoses in this western section for all three geographic categorizations. This overlap of hot spots indicates—at least for this small analysis—that the distribution and concentration of diagnoses for all diagnoses combined as well as NRR versus HET/IDU/CSW diagnoses appear to be similar.

Figure 2. Counts by census tract (n=130) of new diagnoses between January 2009 and June 2014 of HIV among women with an interview record and geocodable address within Baltimore city.

Legend

All Diagnoses (counts)
- 1 - 2 (n=79)
- 3 - 4 (n=27)
- 5 - 6 (n=18)
- 7 - 8 (n=2)
- 9 - 11 (n=4)
- Census Tract
- Water
- Data suppressed

N

0   0.75   1.5   3 Miles

Figure 3. Counts by census tract (n=117) of new diagnoses between January 2009 and June 2014 of HIV among women with an interview record and geocodable address within Baltimore city with no reported risk of exposure (NRR).
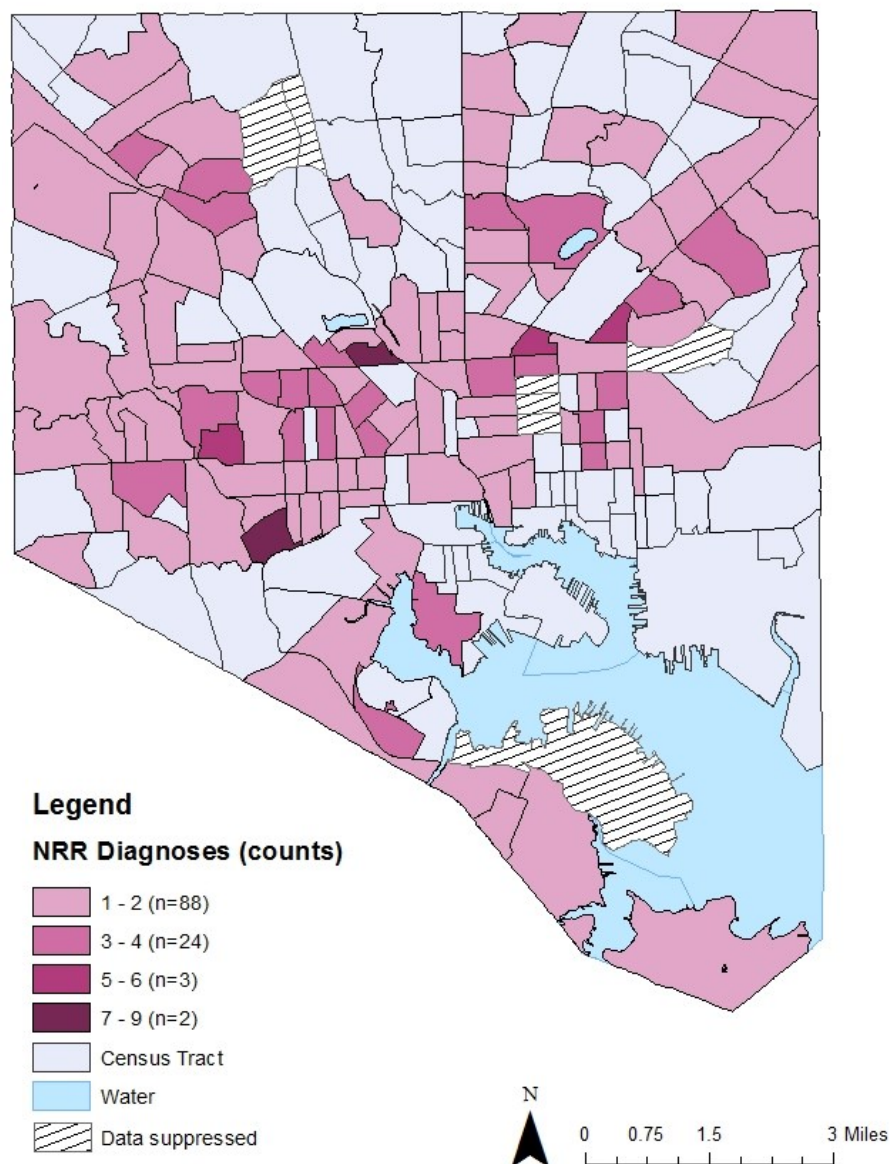
Figure 4. Counts by census tract (n=76) of new diagnoses between January 2009 and June 2014 of HIV among women with an interview record and geocodable address within Baltimore city who reported HET/IDU/CSW.
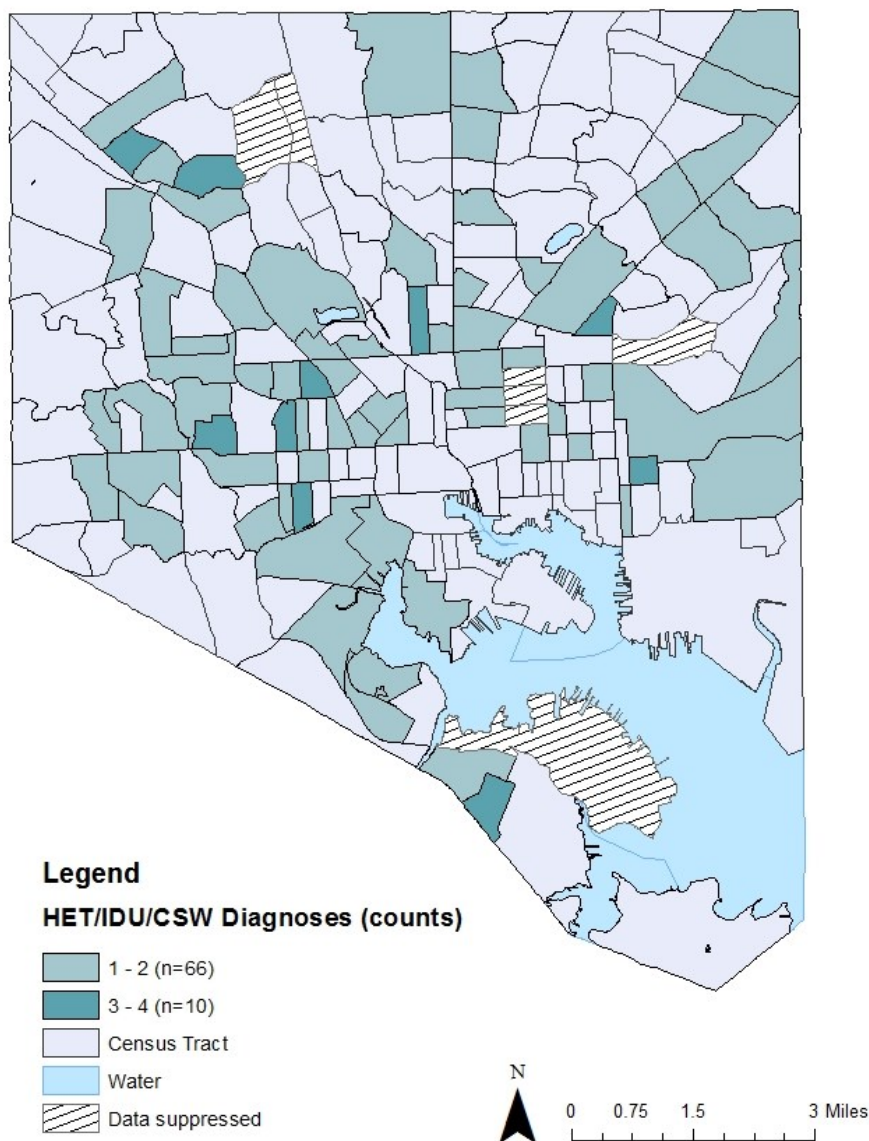
V. Discussion

Several recent studies using data from the latest NHBS-HET cycle suggested that the prevalence of HIV found in Baltimore and Washington, D.C., was evidence that the epidemics in the cities have transitioned from concentrated to generalized among heterosexuals.[42,43] However, a generalized epidemic suggests a very specific definition—meaning that HIV is no longer diffusing from core groups of IDU and MSM to non-IDU and non-MSM partners, but rather is occurring between heterosexuals that are not members of classically-defined risk groups. Using data from NHBS-HET to characterize transmission patterns is a difficult proposition, given that this study was designed to measure prevalence, not transmission patterns.

One study designed to assess transmission of HIV from the high-risk populations of injection drug users and men who have sex with men to non-drug using women found that this 'bridging' was not extensively observed. The study—the Sexual Acquisition and Transmission of HIV Cooperative Agreement Program (SATH-CAP)–was a cross-sectional study conducted in three U.S. sites and one international city that recruited participants using respondent-driven sampling. While the data collected by SATH-CAP indicated that diffusion of HIV from high-risk to lower-risk groups was not extensive, one of the limitations of the study was that it could not distinguish between prevalent versus incident HIV infection.[5]

In a generalized epidemic, we would expect to see that women not assigned an exposure category would be a different population from those assigned to an exposure category. However, the results of this analysis do not suggest that women who can be

categorized as NRR are a different population from those who reported HET/IDU/CSW. Demographic, behavioral and place-based characteristics were similar for women in both groups. Furthermore, our sensitivity analyses did not detect markedly different distributions of characteristics. Our geographic analysis did not indicate that the NRR group is geographically clustered or, indeed, differently distributed from women who reported HET/IDU/CSW.

Of the characteristics where differences were noted between the two groups, several possible explanations exist. Women who were classified as HET/IDU/CSW were more likely to be non-Hispanic white than those classified as NRR (12.9% v. 3.9%). This is due to the fact that IDU were included in the known exposure category—and were more likely to be non-Hispanic white than non-IDU (28.6% of IDU were non-Hispanic white compared to 5.2% of non-IDU women).

Another place where differences were seen was in reported cocaine use. This is also due to categorization of CSW and IDU in the 'known exposure category' group. Numerous studies have linked cocaine use and HIV infection, cocaine use and injection drug use and cocaine use and commercial sex work. In sensitivity analyses, when injection drug users and commercial sex workers were excluded, no difference in substance use was seen.

This study has several limitations that must be considered. First, the final sample size was not large and there was a significant amount of missing data. This could have impacted our findings in a number of ways. First, due to the small sample size, there was limited power to detect differences between the groups. This may be of particular concern

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in the substance use variables when more than 50% of the cases were missing data on substance use. Moreover, data on marital status and education—characteristics that have been previously linked to risk of infection—were extremely limited. While the distribution of these characteristics between groups did appear somewhat different, the amount of missingness made it impossible to detect if this was a real finding or merely a reflection of the data available.

Of the original sample, 40.1% did not have interview data available. These women were excluded because women exposure category classification was significantly different between those who had interview records and those who did not. It was theorized that the low levels of classification of HET/IDU/CSW for women without interview data was due to women being more willing to disclose possible risk factors information during interview. However, it is possible that women who could not be found to be interviewed or who refused to be interviewed are different from those who were interviewed in a way that might impact these findings.

Additionally, exposure category classification is an imperfect science. The CDC uses multiple imputation to categorize women according to mostly likely risk category, with 80.8% being assigned to HET and 19.2% assigned to IDU in national estimates.[44] Therefore, we can assume that some proportion of the women included in the NRR exposure category are non-reporting IDUs, which may have impacted our findings.

A key piece of the puzzle that was not able to be analyzed in this study was sexual network characteristics and network position. As network position and partner characteristics play critical roles in women's risk of acquiring HIV, it is possible that

NRR and IDU/HET/CSW women may differ in terms of sexual network membership, partner characteristics or network position that were not detected in this study.

VI. Conclusions

More research is needed in order to better characterize the heterosexual HIV epidemic in Baltimore. While this study offers some evidence that the heterosexual HIV epidemic remains concentrated around sexual networks populated with IDU and MSM, the data analyzed in this study were not specifically collected to measure transmission. More research examining transmission dynamics is critical to better understanding how HIV acquisition is occurring among heterosexual women in the United States.

Suggestions of a generalized epidemic are predicated on the notion that HIV transmission is occurring through chains of low-risk heterosexual contacts, rather than diffusing from a core group. The lack of strong evidence pointing towards diffuse chains of transmission among non-IDU and non-MSM heterosexuals suggests that prevention and treatment strategies geared toward a concentrated epidemic may still be the most effective tools. In generalized epidemics, broad prevention efforts must target the sexually active population and large-scale outreach must be conducted. In concentrated epidemics, targeted HIV prevention campaigns may be used in order to vigorously work to identify and treat HIV cases in order to attempt to halt transmission.

Targeted control efforts have been used to good effect in HIV epidemics—for instance, implementing testing and treatment outreach and needle exchange have proved effective in many settings in the United States in reducing HIV incidence among IDU. More generalized prevention efforts—including prevention programs targeting risk

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behaviors by the CDC—have proved to be of limited effectiveness and difficult to implement.[45,46,47] Targeted HIV control aims to interrupt HIV transmission chains by locating and focusing efforts on those at highest risk of either transmitting or acquiring HIV, an approach which has been demonstrated to be more cost-effective at stopping transmission that broad prevention efforts.[48] The evidence still suggests that identifying new methods and strategies to more effective locate, test and link newly-positive individuals with care may be the most effective and cost-effective methods of reducing HIV incidence in Baltimore.

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