Portrait of HIV for the east region of Tennessee

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BACKGROUND

Scope

Although great strides have been made in the treatment and prevention of the human immunodeficiency virus (HIV), HIV remains prevalent in the United States. An estimated 1.1 million people are currently infected with HIV in the U.S.,[1] and 50,000 new infections are estimated to occur each year.[2] Although HIV is typically associated with large urban areas, an increasing number of cases are occurring in the rural South.[3,4,5] The Centers for Disease Control (CDC) estimated that as of 2013, 839 adults and adolescents were diagnosed with HIV in Tennessee, ranking it 15th among all 50 states. Tennessee's HIV population was 63.3% black, while whites and Hispanic/Latin Americans made up 31% and 4.6% of the population respectively.[6]

Modes of Transmission

HIV is transmitted in a variety of ways through the body fluids of persons infected with HIV, including blood, semen, pre-seminal fluids, rectal fluids, vaginal fluids, and breast milk.[7] The most common modes of transmission include men who have sex with men (MSM), intravenous drug use (IDU), heterosexual contact (HET), and perinatal contact. MSM constitute an estimated 63% of cases in the U.S.[8] and 68.9% of cases in Tennessee.[6] In rural areas, MSM face a number of challenges, such as stigmatization and discrimination,[9,10] which may lead to adoption of risky sexual behavior as a coping mechanism to mediate psychological stress.[11] Such behavior would further enhance risk of HIV for rural residents in the MSM population.

Aside from MSM transmission, substance use is also a risk factor for HIV infections, as it increases the likelihood of high-risk sex with HIV-infected partners.[12] Intravenous drug users (IDUs) have a particularly high risk to acquire HIV.[8] Because HIV is a blood-borne pathogen,

people who inject drugs and are diagnosed with HIV can transmit the virus to other individuals if they share the same needle that was exposed to HIV-infected blood and not properly sterilized. Among rural Appalachians, injection drug users rapidly progress from their first illicit drug use to the first injection drug use, with a median time of just three years.[7] Of injected drugs, synthetic opioids like oxycodone are quite prominent.[13] Rural populations have shown to be at risk for rapid incidence of HIV from IDU transmission. In 2015, 135 cases of HIV infection were reported in a community outbreak in Indiana, and 80% of those infected reported IDU. A high portion of those infected were adults who did not complete high school (21.3%) and were living in poverty (19.0%).[14] Although IDUs are only estimated to account for 2.9% of HIV transmission in Tennessee,[6] rapid transmission of HIV like that evidenced in Indiana is possible for the state, as Tennessee ranks highest for painkiller prescriptions per capita among all states (143 prescriptions per 100 persons).[15]

While MSM and IDU are the most prevalent modes of transmission, a number of other modes of HIV transmission also occur, including heterosexual contact and perinatal exposure. HIV can also be spread through vaginal, oral, and anal sex. Furthermore, HIV transmission can occur from an HIV-infected mother to infant in a number of manners, including childbirth.[7]

HIV in the South

Those living in the South are at greater risk of HIV mortality than other areas of the United States. In a cross-sectional analysis of HIV deaths from 2001-2007, nine of the ten states with the highest case-fatality rates were located in the southern United States, including Tennessee.[16] A number of explanations for this disparity exist. A prominent explanation concerns the large proportion of rural areas in the South compared to other regions in the United States. Comparing HIV testing between urban and rural areas, individuals residing in rural areas

were less likely to receive HIV testing, potentially leading to later diagnosis of HIV in rural areas.[17] Later diagnosis may contribute to the higher rate of mortality. Patients with HIV who live in rural areas have higher mortality rates than urban patients with HIV despite similar CD4 counts at presentation and while controlling for age, sex, race, and HIV risk factors.[18] Demographics of HIV patients are also different in the rural South compared to the urban South. For example, South Carolina rural HIV residents were more likely to be black, non-Hispanic, and female than urban residents.[19]

HIV Treatment

Since HIV first surfaced in the United States in the early 1980s, much has changed concerning the knowledge of the virus, its risk factors, and treatment. During the early stages of the HIV epidemic, infections mostly consisted of white MSM and male IDUs.[20] The HIV treatment drug Azido-Thymidine (AZT) was first approved by the Food and Drug Administration (FDA) in March of 1987.[21] An estimated 19.1 million lives between 1990 and 2013 have been saved.[22]

In 1996, highly active antiretroviral therapy (HAART) was implemented and dramatically changed the outlook of HIV/AIDS treatment.[23] HAART actively controls viral loads, delaying the diagnosis of AIDS. Since it has been in use, a diagnosis of HIV has shifted from a terminal illness to a manageable condition. The effectiveness of potent medications has brought on other new challenges as well. Because HAART needs to be taken daily in order to be effective, patients often do not take their medication as advised.[24] Some patients also falsely believe that using HAART eliminates their risk of transmission and, in turn, may resume unsafe sexual practices[25] and injection drug use.[26]

Together, medical advances and HIV awareness have changed the demographics of persons diagnosed. Since 2005, researchers have observed an estimated 17% increase of HIV diagnoses among MSM.[20] Moreover, while HIV infections were generally concentrated in urban areas, greater infection has begun to occur among rural populations especially in the South.[3]

Populations at Risk

As previously mentioned, men who have sex with men and intravenous drug users have the highest risk for HIV infection. These populations are predominantly males. Women are at risk mainly from heterosexual contact with an HIV infected partner. In 2010, 86 percent of female infections were attributed to heterosexual transmission.[20] Furthermore, HIV among women has become more problematic in the South with steadily increasing HIV incidence and mortality.[27]

HIV infections disproportionally affect ethnic minorities – notably, African-Americans. As of 2010, African-Americans accounted for a higher proportion of HIV infections than any other population at all stages from diagnosis to death.[20] The majority of these infections have occurred in men, but African-American women also had a diagnosis rate 20 times higher than white women. Explanations of this inequity vary. One highlights the higher prevalence among the African-American community in general and posits that one is more likely to become infected simply by choosing a partner within his or her own community.[28] Another points out that African-Americans are typically diagnosed at later disease stages, which causes them to start therapy later than recommended. Finally, African-Americans are more likely to discontinue treatment once started.[29]

While gender, sexual orientation, and ethnicity may increase one's risk to acquire HIV, risk also varies by age. Among adolescents and young adults (13-24), 69.5 per 100,000 are

infected with HIV, with the majority of incident cases again occurring among African-Americans (57.4%). Alarmingly, despite the high rate of HIV infection among youth, more than half (59.5%) were estimated to be unaware of their infection.[30] HIV also disproportionally affects youths geographically. Southern youth have significantly higher HIV rates (77.6 per 100,000) than the nation's youth overall (69.5 per 100,000).[30] The high prevalence of HIV among youth may be related to vulnerability of the life stage, as youth are more prone to peer pressure, risky sexual behavior, and drug use.[20]

Persons 50 years or older represented 16% of all incidence of HIV diagnosis in the United States in 2010,[31] an increase since 2000. Some argue that older people – as well as their medical providers – may discount their risk for infection and therefore engage in unsafe health practices that put them at further risk.[20] Alternatively, medication advances have allowed those diagnosed with HIV to live longer, well beyond the 5th decade. As of 2014, the over-50 population made up slightly less than half (42.8%) of all HIV prevalent cases.[32]

HIV/HCV Coinfection

Compounding the problem for HIV patients is the risk for coinfection with the hepatitis C virus (HCV). Like HIV, HCV is a blood borne pathogen, thus sharing HIV transmission routes like men who have sex with men[33] and intravenous drug use.[34] HIV/HCV coinfection has typically occurred in large urban areas like New York,[34] Chicago, and Los Angeles,[33] but a number of predominantly rural Appalachian states including Tennessee, Kentucky, Virginia, and West Virginia have seen a dramatic increase in HCV.[35] Such evidence suggests a high prevalence of HIV/HCV coinfection could be occurring as well.

Objective

Data indicate that HIV prevention and treatment are improving in the United States, but it is not certain if these improvements are consistent across the nation. Rural and remote areas like East Tennessee may not show the same benefits of the advancements of medical care and public health policies. This thesis aims to describe the characteristics of a largely rural and medically underserved population in Tennessee. Furthermore, this project aims to describe the epidemiology and risk factors of HIV for the 16 counties that make up the Appalachian region of East Tennessee. Lastly, differences in characteristics between counties will be represented spatially using geographic information systems (GIS) analysis. Such analyses assist local public health officials to prioritize geographic regions and examine trends to gauge improvement and better prevent future outbreaks.

METHODS

This study reflects data from the electronic HIV/AIDS Reporting System (eHARS) and the National Disease Electronic Surveillance System (NEDSS). All living individuals who resided within the 16 county region of East Tennessee and were diagnosed with HIV or AIDS as of 2014 were included in the analysis. The 16 counties included Anderson, Blount, Campbell, Claiborne, Cocke, Grainger, Hamblen, Jefferson, Knox, Loudon, Monroe, Morgan, Roane, Scott, Sevier, and Union. Internal Review Board (IRB) approval was received from the University of Tennessee – Knoxville. All data were deidentified prior to analysis.

Measures

Those who had listed “white” as their primary identified ethnicity were categorized as such, while the same was done for those who had listed “black.” All other races were identified as “other.” Gender was based on the individual’s birth sex. Age of diagnosis was defined as the person’s when age he or she received the HIV diagnosis, and current age was defined as the

person's age in December 2015. Initial CD4 counts reflected CD4 counts at the time of diagnosis. The first assessed and most recent viral load counts were also used.

Insurance attainment was categorized if the patient had any type of medical insurance during treatment. Types of insurance included, CHAMPUS, CHIPS, Medicare, Medicaid, private insurance, state funded insurance, or VA insurance. Variables for both HIV and AIDS insurance were included in the dataset. Any individuals who listed any type of these insurances either for HIV, AIDS, or both were categorized as insured.

HCV data were extrapolated from the National Disease Electronic Surveillance System (NEDSS). HCV cases were correctly matched with the same case in the eHARS dataset prior to the analysis. HIV/HCV coinfection cases were identified if an individual had ever received a diagnosis for HCV. These included HCV acute confirmed cases, as well as HCV chronic confirmed or probable cases. The eHARS and NEDSS data did not include negative HCV testing results, nor were all cases tested for HCV, so cases not defined as HIV/HCV positive were categorized as unknown.

Mode of exposure for HIV infection was classified under 11 different exposure categories: MSM, IDU, heterosexual contact (HET), MSM/IDU, IDU/HET, MSM/HET, MSM/IDU/HET, Perinatal Transmission, Other, Not Identified, and Not Reported. Clinicians associated with the eHARS medical team determined mode of transmission based on self-report, patient interviews, and interviews with the patient's family. Each particular mode of transmission was then categorized as its own variable. For example, IDU classification reflected all cases with IDU identified either alone or with other transmissions. The same was done for MSM and HET.

In order to assess change in HIV risk factors over time, date of diagnosis was categorized into three 10 year time periods: (1) 1984-1994, (2) 1995-2004, and (3) 2005-2014. Risk factors

were also assessed across the age of diagnosis spectrum. Age of diagnosis was categorized into four different age intervals: (1) 12 and younger, (2) 13-24, (3) 25-49, and (4) 50 and older.

Analysis

All quantitative analyses were conducted using SPSS version 22.[36] Descriptive analyses, including both categorical and continuous variables, were used to describe the population. Categorical variables included gender, race, current age, age of diagnosis, HIV/HCV coinfection, medical insurance, and mode of exposure. Continuous variables include CD4 counts and both initial and most recent viral loads. Chi-squared analyses were conducted in order to assess the association of year of diagnosis with gender, race, HIV/HCV coinfection, mode of exposure, and MSM, IDU, and HET exposures.

Spatial analysis was conducting using ArcGIS 10.3.[37] All cases were examined by the 16 counties of current residence. Intervals of five graduated colors were used to show differing frequency, percentage, or rate. Frequencies for the number of HIV cases by county are shown in each of the counties. Estimated resident populations as of 2014 for each of the 16 counties were pulled from U.S. Census Data.[38] Rates of HIV per county were determined based on these population statistics and normalized to reflect values per 10,000 people.

The stratification of year and age of diagnosis is also represented spatially by county. Percentages were determined for both age and year of diagnosis based on the number of persons infected with HIV for each county respectively. Percentages were also determined for MSM exposure, IDU exposure, HET exposure, race, and gender. Percentages of HIV/HCV coinfection and insurance coverage of those diagnosed with HIV were also determined by county.

RESULTS

The sample included 1548 cases. Of these, the vast majority were males (N = 1238, 80.0%) and white (N = 1197, 77.2%). Black individuals made up 315 cases (20.3%), while the remaining 30 cases (1.9%) were categorized as other. Eight cases were missing data for race (N = 1540). The mean age of diagnosis was 34.6 years (range = 0-79, SD = 10.85), and the mean current age was 46.9 (range = 1-85, SD = 11.72). Of the cases, 259 (16.7%) had some type of insurance, and 90 cases (5.8%) were positive for HIV/HCV coinfection. The mean CD4 value was 15822.6 (N = 1430, range = 0-2360000, SD = 324.3). For viral loads, the first detected viral loads mean level was 880886.98 (N = 1333, range = 19-1000000000, SD = 27390768.09), and the recent viral load mean level was 15822.6 (N = 1399, range = 0-2360000, SD = 104381.18).

Spatial analysis by county (Figure 1) revealed that Knox County had the most cases of HIV with 875. Anderson, Blount, and Sevier County all fell within the 58-129 cases category and represented the highest frequencies behind Knox County. Knox County also showed the highest rate, with 19.5 cases per 10,000 people (Figure 2). Anderson County had the second highest rate of 13.1 per 10,000. Most counties (N = 8) had a rate between 7.2-10.2.

Female HIV rates are spatially represented in Figure 3. Knox County showed the highest rate of female HIV diagnoses (7.78 per 10,000), while Anderson, Blount, Cocke, Loudon, and Monroe County showed rates of 3.37-5.66 per 10,000. Rates of black HIV diagnoses were highest for Morgan County (Figure 4; 124.78 per 10,000). Scott County was the most likely to have insurance (66.7%), while Monroe (12.8%) and Morgan (8.3%) were the least likely to be insured (Figure 5). HCV/HIV coinfection was more prevalent in Claiborne (25.0%) and Morgan County (16.7%), while Campbell, Loudon, Roane, and Sevier County showed percentages from 5.9%-11.3% (Figure 6).

Year of diagnosis was categorized into three different groups. From 1984 to 1994, 225 (14.5%) individuals were diagnosed with HIV. Between 1995-2004, 657 (42.4%) individuals were diagnosed with HIV, and the remaining 666 (43.0%) cases were diagnosed from 2005 to 2014. Those diagnosed from the ages of 0 to 12 made up 24 cases (1.6%); 234 (15.1%) cases were diagnosed between the ages of 13-24, while 1166 (75.3%) were diagnosed between the ages of 25-49. The remaining 123 (8.0%) cases were diagnosed at 50 or older.

Percent of HIV diagnosis by year of diagnosis was shown in Figure 7. The years between 1984-1994 show that Anderson, Blount, Grainger, Hamblen, Monroe, Morgan, and Roane County had a high rate of their HIV cases occur in this time period, while Union and Cocke County had a low rate. With respect to the years between 1995-2004, Cocke, Grainger, Morgan, and Roane County showed a high proportion of HIV cases, while Scott County showed a low proportion. Lastly, between 2005-2014, counties in the northern part of the region – such as Anderson, Campbell, Claiborne, Hamblen, Scott, and Union County – evidenced a high proportion of HIV cases. Contrastingly, during the same time frame, Grainger, Morgan, and Roane County showed a low proportion of HIV cases.

Percent of HIV diagnosis by age of diagnosis was shown in Figure 8. Cocke County showed the highest percentage of cases occurring between 0-12 (6.3%), while Loudon (4.3%) and Monroe (5.1%) showed moderately high percentages. For ages of diagnosis between 13-24, Scott County showed the highest percentage (22.2%). All counties had the majority of HIV diagnoses occur from ages 25-49. Of these, Claiborne (87.5%) and Roane (84.2%) had the highest percentage of cases occurring between 25-49. Campbell (80.0%) and Monroe (79.5%) County showed moderately high percentages for this age category. Of those 50 and older, Union

County had the highest percentage represented (25.00%). Blount, Campbell, Grainger, and Jefferson Counties showed slightly lower percentages (8.75%-17.30%).

Mode of exposure was spatially represented for each county. Percentages of HIV diagnoses by MSM (Figure 9) were most prevalent in Claiborne, Grainger, Hamblen, and Scott Counties (67.5%-88.9%), while rates of HIV diagnoses by IDU (Figure 10) were most prevalent in Campbell (28.0%) and Morgan County (29.2%). Cocke and Monroe County showed rates of those infected by of heterosexual contact (Figure 11; 25.0%-35.9%).

Chi-squared analysis revealed that mode of exposure, HIV/HCV coinfection, IDU transmission, and heterosexual transmission differed significantly by year of diagnosis (Tables 1-4). Gender, race, and MSM transmission did not significantly differ by year of diagnosis (Tables 5-7).

With respect to mode of exposure (Table 1), the percentage of MSM and HET transmission was relatively consistent across the three diagnostic time periods ($\chi^2 = 144.300$; df = 20; p = .000), while the percentage of IDU significantly differed by year of diagnosis from 1995-2004 (7.6%) to 2005-2014 (2.4%). A significant difference occurred across year of diagnosis for mode of exposure not reported, with a higher percentage occurring in the 2005-2014 period (13.5%). Percentages of cases for HIV/HCV coinfection have differed by time of diagnosis ($\chi^2 = 5.985$; df = 2; p = .050), with the greatest proportion (9.3%) occurring for those diagnosed in the 1984-1994 period. In the 2005-2014 period, that percentage decreased to 5.1%.

IDU transmission differed across year of diagnosis (Table 3), with 19.1% reflected in 1984-1994 and 14.9% reflected for the 1995-2004 period. Comparably this proportion was 6.5% in 2005-2014 ($\chi^2 = 35.721$; df = 2; p = .000). Heterosexual transmission showed a different pattern than IDU transmission across period of diagnosis (Table 4). Percentages of heterosexual

transmission jumped from 17.8% to 23.3% between 1984-1994 and 1995-2004, but were falling to 15.8% for the 2005-2014 period ($\chi^2 = 12.405$; df = 2; p = .002).

Chi-squared analysis revealed that mode of transmission, MSM transmission, gender, and race significantly varied across age intervals (Tables 8-11). HIV/HCV coinfection, IDU and heterosexual transmission did not differ significantly across age intervals (Tables 12-14).

Perinatal transmission was most prevalent for the 0-12 age group (83.3%), while MSM transmission was most prevalent for persons 13 and older (45.2%-57.8%) (Table 8; $\chi^2 = 1275.929$; df =30; p = .000). IDU was most prominent in the 25-49 group (6.1%), and heterosexual transmission is most prominent in the 13-24 group (16.2%). Cases not reported differed by age, with higher percentages occurring with increased age. For cases of MSM transmission (Table 9), with or without IDU or heterosexual transmission, the most prevalence was among the 13-24 (62.4%) and 25-49 (62.8%) age groups ($\chi^2 = 47.73$; df = 3; p = .000). Prevalence was lower than average for persons diagnosed 50+ (48.4%).

The proportion of females differed with age of diagnosis (Table10; $\chi^2 = 27.784$; df =3; p = .000). Of those diagnosed between the ages of 0-12, 50.0% were females. That percentage was 25.2% for those diagnosed between 13-24, but this group also showed the highest percentage of females infected at 13 and older. For those diagnosed between 25-49 and 50+, the percentages were 18.4% and 19.4% respectively. Race varied by age (Table 11), as the percentage of whites differed with age of diagnosis ($\chi^2 = 19.861$; df =6; p = .003). Whites had the greater representation for the older HIV cases (82.1%). The majority of HIV cases were diagnosed from ages 25-49 among all races.

DISCUSSION

The study results characterize the prevalent HIV cases of East Tennessee, as well as how these characteristics differed by age and period of diagnosis. Results also show how these characteristics differ by county of residence. These analyses provide critical support to better understand HIV in the South, where HIV cases disproportionally occur.[3,4,5] Moreover, the demographics of East Tennessee very much resemble demographics of areas with recent HIV outbreaks.[15,19] These findings can potentially help prevent future HIV outbreaks.

Demographic Differences

Persons diagnosed with HIV in this 16 county region in East Tennessee were significantly more likely to be white (77.2%) than the state of Tennessee as a whole (31.0%). This is in keeping with the demographics of East Tennessee. For example, Knox County – the region's most diverse county – is still 86.3% white.[38] This is nearly 10% higher than the statewide percentage of white individuals (78.9%).[38] However, the percentage of white diagnoses did not correlate with the percentage of white population in each county. Morgan County, with only 3.7% of its population listed as black,[38] had the highest rate of black HIV diagnoses (124.78 per 10,000) for this region. Although whites made up the majority of those living with HIV in East Tennessee, blacks still had higher rates of HIV, which is similar to the current literature.[20]

Insurance coverage was also very low in this population. Only 16.7% of HIV cases reported insurance. This percentage of insured patients is particularly concerning give the implementation of the Affordable Care Act. While Tennessee chose not to expand Medicaid, this percentage is still lower than necessary for those managing a chronic disease.

Compared to the state as a whole (2.9%),[6] this 16 county region displayed a higher proportion of HIV diagnoses transmitted associated with IDU (11.9%). This disparity may be

attributed to the higher number of intravenous drug users in Appalachia compared to the state as a whole, as Tennessee ranks second among all fifty states for prescription opioids – which can be crushed and administered intravenously – per capita (143 per 100).[15] Interestingly, some of the more rural counties (e.g., Campbell, Morgan) evidenced a greater percentage of HIV infection by IDU than more urban counties. Rural counties also displayed a high proportion of HCV/HIV coinfection, supporting the suggested link between IDU and HCV.[34]

Changes across Time

Through the three diagnosis periods, the number of IDUs, HETs, and HCV/HIV coinfection have changed. In the case of IDU, the fewer cases of HIV transmitted by IDU mirrors that of the national data.[20] This difference in IDU transmission may correlate with the decrease in HCV/HIV coinfection. IDU is the primary mode of transmission,[34] and 20.7% of all those diagnosed with HIV by IDU in the sample were coinfected with HCV compared to the 3.8% of those coinfected that were not IDUs. IDU decrease has been attributed to the increase in syringe exchange programs and substance abuse treatment. However, Tennessee does not offer syringe exchange programs at the state level. In fact, there is only one syringe exchange program in the state located Nashville, which is not in the 16 county region of this study.[39] Nevertheless, residence reflects current location, so persons could have been diagnosed elsewhere – such as a location with syringe exchange programs – and then migrated to this 16 county region. It is alos possible that person who contract HIV via IDU may be less compliant with their medication and thus have a greater mortality risk. Only people who are living with HIV or AIDS are included in these data. Finally, the number of cases not reported is highest for the 2005-2014 period, which may also attribute to the low percentage of IDU transmission during this time.

MSM, IDU, and HET transmission were reflected in the greatest number of cases in the 1995-2004 diagnosis period. This is perhaps due the high number of total HIV diagnoses for this time frame. While rates for HIV diagnoses decreased dramatically for later decades, the percentage reflecting MSM and HET transmission only slightly decreased. Perhaps efforts to decrease IDU diagnoses – like substitution therapy and awareness programs – have been successful throughout the region. Moreover, further efforts for HIV prevention should be concentrate on sexual health.

The percentage of cases whose transmission was not reported differs across the three diagnosis periods, with higher percentages occurring in the 2005-2014 period. Clinicians may possibly need time to determine the correct modes of transmission. For these cases, the mode of transmission may be updated if the patient becomes more comfortable with disclosure.

Changes across Age of Diagnosis

Mode of transmission, MSM transmission, gender, and race significantly differed by age of diagnosis. All modes of transmission showed highest percentages among the 25-49 age group. For MSM, this may reflect an increased comfort of homosexual acts with age. Individuals who engage in this type of behavior may not feel comfortable doing so until a later age due to negative societal pressure. Persons within the 25-49 age group may also be more accepting of gay rights, and therefore more comfortable reporting this experience, than older individuals. Comfort of sexual behavior may increase in general, leading to increases in heterosexual transmission. For IDUs, substance use may start in age group 13-24 more generally, with substances like marijuana and alcohol.[40] Transition to substances that are administered intravenously may not occur until age 25, accounting for the high number of IDUs diagnosed

with HIV in this age group. The 25-49 group also is a large age range, which contributes to the greater number of cases in this group compared to the remaining three smaller age populations.

The percentages of females diagnosed with HIV changed with age of diagnosis. The distribution was equal ages 0-12, where the majority of case (83.0%) occurred via perinatal transmission. The inequity of diagnoses between males and females reflects the gender exclusive transmission by MSM. Concerning race, all races were more likely to be diagnosed between ages 25-49. Blacks accounted for 25.8% of all HIV diagnoses between 13-24 in this study, and this percentage is smaller with increasing age of diagnosis. Individuals diagnosed in the 13-24 age group are more likely to receive TennCare than their older counterparts,[41] increasing their likelihood of treating and living with HIV. Persons who have died after an HIV diagnoses are not included in the study, which may account for the low percentages among older blacks as they are less likely to receive treatment.[29]

The percentage of cases not reported differed by the age of diagnosis cohort. Persons 50 and older showed a significantly higher percentage of cases not reported. Such results could stem from older individuals being harder to reach in terms of data collection. Moreover, the older individuals may also feel more stigmatized based on their HIV diagnosis and be reluctant to speak with clinicians attempting to determine the mode of transmission compared to younger people.

County Disparity

Knox County may benefit most through prevention efforts as this county has both the highest frequency and rate of HIV diagnosis. However, because the sample is limited to prevalence data, this could also mean that Knox County provides better care for those diagnosed with HIV than the surrounding counties. This would not only extend the survival period, but

those diagnosed with HIV in a surrounding county may move to Knox County after learning of their diagnosis. Urban areas typically provide better access to treatment facilities without the need of traveling long distances.

Most counties saw the greatest percentage of surviving HIV cases being diagnosed from 1995-2004. However, northern counties such as Anderson, Campbell, Claiborne, Hamblen, Scott, and Union County saw high percentages occurring from 2005-2014. This could suggest that HIV is beginning to spread into more rural areas. Furthermore, this could also mean that persons diagnosed with HIV in these counties have greater mortality rates due to more challenging healthcare access. Because persons diagnosed with HIV who are deceased are not included in the sample, this could account for low percentages from 1984-2004. Those diagnosed earlier may also have moved to more urban counties to receive care as their HIV progresses.

Overall, these analyses also aid in prevention measures for each of the 16 counties. Local public health departments can see which variables are highest in their respective population and use them for more effective prevention efforts. For example, Campbell, Loudon, Morgan, and Sevier County showed the high percentages of HIV diagnoses by IDU, so prevention efforts among these populations may be more effective if they are focused on substance use. Among these, Campbell, Loudon, and Morgan all showed a higher percentage of HCV coinfection among those diagnosed with HIV. Thus, prevention efforts may double for both HIV and HCV.

Percentages of MSM transmission were highest in Claiborne, Grainger, Hamblen, and Scott County (67.51%-88.89%). These are primarily rural areas, where MSM is more likely to be stigmatized. Residents may be reluctant to discuss their sexual health, and even use sexual behavior to cope with discrimination.[10,11] Rates of female diagnoses by county roughly

correspond to percentages of HIV by HET transmission per county. Counties with both high rates of female and high percentages of HIV diagnoses by HET include Anderson, Cocke, Knox, and Monroe. This is similar to the national population, where 86% of HIV transmission among females occurs via HET transmission.[20] Rates of black diagnoses were highest in Morgan County despite having a low black population (3.7% of 21,987).

LIMITATIONS

Despite these findings, this study has limitations. First, the data reflect only prevalent cases, which are valuable in order to understand the characteristics of the current population. Those diagnosed in the early years of HIV infection (i.e., 1980s) are more likely to have died due to the infection and are not included in the sample. This may skew results for modes of transmission like IDU. IDUs are less likely to receive HAART treatment than non-IDUs,[20] which would also decrease the representation of IDUs within the sample. Although the percentage of HIV transmitted by IDU in this sample (11.9%) are higher than the state average (2.9%), this could be higher if all deceased cases were included within the sample.

Mode of transmission was determined based on self-report, patient interviews, and family interviews, which yields the possibility for error. This is likely reflected in the Not Identified and No Reported Risk categories that show higher percentages with higher age. Such a limitation does not allow the study to provide a full picture of the characteristics of current cases in the east region.

The modifiable areal unit problem (MAUP) is a statistical bias that affects the validity of GIS data in this sample. This stems from the idea that the data are aggregated into counties based on current address. These addresses can be modified, so an individual that currently resides in a certain county may have contracted HIV in another county. Moreover, individuals residing in a

certain county may not be an exact reflection of that county. He or she may live on the border and use the better resources of the neighboring county rather than the one in which he or she currently resides. Facilities in neighboring counties may also be closer than ones in the individual's current county of residence. Individuals can cross county boundaries as well, perhaps sharing needles residents from different counties or connecting with sexual partners residing in a different county.

FUTURE RESEARCH

Research is necessary to decrease the risk of HIV epidemics like those in and South Carolina[3] and Indiana.[14] These predominantly poor, rural, and white demographics are quite similar to the one included in this sample and suggest that the 16 county region of East Tennessee could be at an equal risk. Furthermore, Appalachian regions such as this one have shown recent high rates of HCV.[35] However, while recent work has been done on strictly HCV in Appalachia, no work has been done for HCV/HIV coinfection in this region. Because those diagnosed with HIV are at an increased risk for HCV,[34] and HCV rates are currently high in the region, it is important that examination of HIV/HCV coinfection be done. Lastly, future work should examine if the rate of insurance increases with the Affordable Care Act.

CONCLUSION

While HIV is now a treatable disease, those in the rural South seem to be disproportionally affected.[5] Recent outbreaks in largely poor, rural, and heavily white concentrated areas have caused concern for similar areas in the U.S. Of these, East Tennessee has demographics that resemble those that have seen recent outbreaks. Using eHARS prevalence data, results showed that those infected by HIV in East Tennessee are predominantly white and male. The majority of cases occurred among those diagnosed from ages 25-49 and in the 1995-

2004 diagnosis period. Targeting would be most effective among the 25-49 population, since it showed to be the predominant age of diagnosis. Insurance rates were quite low, which is alarming even with the lack of complete data. Only 16.7% of those claimed insurance coverage, despite the implementation of the Affordable Care Act.

The majority of cases occurred via MSM transmission, but the percentage of those infected by IDU transmission is higher than the state of Tennessee as a whole. Rates among blacks showed disproportionately high rates in some counties. Screening should be utilized by public health departments based on rates of certain variables (i.e., African-Americans, IDUs) for each county. Knox County had both the highest frequency and rate of HIV diagnoses of the 16 counties, which implies that focused prevention could be effective here but that this county has a lower mortality rate than surrounding counties. Funding for HIV treatment in Knox County, as well as counties with high HIV prevalence rates should be provided due to the number of people seeking medical care. Future research should continue to examine statistics of this population in order to design more effective prevention efforts. Because rates of HCV coinfection have also shown to be high in the region, the potential for increasing rates of HCV/HIV coinfection is possible. Further efforts should be made both to collect HCV/HIV coinfection data, and also to prevent future transmission.

TABLES

Table 1
Type of Exposure by Year of Diagnosis
(N = 1548)

	Exposure Category										
	MSM	IDU	Het	MSM/ IDU	IDU/ HET	MSM/ HET	MSM/ IDU/ HET	Peri	Other	Not identified	Not reported
1984-1994	132 (58.7%)	18 (8.0%)	22 (9.8%)	10 (4.4%)	12 (5.3%)	3 (1.3%)	3 (1.3%)	5 (2.2%)	3 (1.3%)	16 (7.1%)	1 (0.4%)
1995-2004	355 (54.0%)	50 (7.6%)	105 (16.0%)	15 (2.3%)	30 (4.6%)	15 (2.3%)	3 (0.5%)	8 (1.2%)	1 (0.2%)	62 (9.4%)	13 (2.0%)
2005-2014	374 (56.2%)	16 (2.4%)	87 (13.1%)	16 (2.4%)	6 (0.9%)	7 (1.1%)	5 (0.8%)	8 (1.2%)	1 (0.2%)	56 (8.4%)	90 (13.5%)
Total	861 (5.6%)	84 (5.4%)	214 (13.8%)	41 (2.6%)	48 (3.1%)	25 (1.6%)	11 (0.7%)	21 (1.4%)	5 (0.3%)	134 (8.7%)	104 (6.7%)

$\chi^2 = 144.300$; df = 20; p = .000

Table 2
HCV by Year of Diagnosis
(N = 1548)

	No HCV Diagnosis	HCV Diagnosis
1984-1994	204 (90.7%)	21 (9.3%)
1995-2004	622 (94.7%)	35 (5.3%)
2005-2014	632 (94.9%)	34 (5.1%)
Total	1458 (94.2%)	90 (5.8%)

$\chi^2 = 5.985$; df = 2; p = .050

Table 3
IDU by Year of Diagnosis
(N = 1548)

	No IDU	IDU
1984-1994	182 (80.9%)	43 (19.1%)
1995-2004	559 (85.1%)	98 (14.9%)
2005-2014	623 (93.5%)	43 (6.5%)
Total	1365	184 (11.9%)

$\chi^2 = 35.721$; df = 2; p = .000

Table 4
Heterosexual Transmission by Year of Diagnosis
(N = 1548)

	No HET	HET
1984-1994	185 (82.2%)	40 (17.8%)
1995-2004	504 (76.7%)	153 (23.3%)
2005-2014	561 (84.2%)	105 (15.8%)
Total	1250 (80.7%)	298 (19.3%)

$\chi^2 = 12.405$; df = 2; p = .002

Table 5
Gender by Year of Diagnosis
(N = 1548)

	Female	Male
1984-1994	36 (16.0%)	189 (84.0%)
1995-2004	144 (21.9%)	513 (78.1%)
2005-2014	130 (19.5%)	536 (80.5%)
Total	310 (20.0%)	1238 (80.0%)

$\chi^2 = 3.852$; df = 2; p = .146

Table 6
Race by Year of Diagnosis
(N = 1540)

	White	Black	Other
1984-1994	173 (77.9%)	47 (21.1%)	2 (0.9%)
1995-2004	509 (78.1%)	134 (20.6%)	9 (1.4%)
2005-2014	513 (77.0%)	134 (20.1%)	19 (2.9%)
Total	1195 (77.6%)	315 (20.5%)	30 (1.9%)

$\chi^2 = 5.272$; df = 4; p = .261

Table 7
MSM by Year of Diagnosis
(N = 1548)

	No MSM	MSM
1984-1994	77 (34.2%)	148 (65.8%)
1995-2004	269 (40.9%)	388 (59.1%)
2005-2014	264 (39.6%)	402 (60.4%)
Total	610 (39.4%)	938 (60.6%)

$\chi^2 = 3.198$; df = 2; p = .202

Table 8
Type of Exposure by Age of Diagnosis
(N = 1548)

	Exposure Category										
	MSM	IDU	HET	MSM/ IDU	IDU/ HET	MSM/ HET	MSM/ IDU/ HET	Peri	Other	Not identified	Not reported
0-12	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (83.3%)	0 (0.0%)	3 (12.5%)	1 (4.2%)
13-24	131 (56.0%)	10 (4.3%)	38 (16.2%)	9 (3.8%)	6 (2.6%)	5 (2.1%)	1 (0.4%)	1 (0.4%)	2 (0.9%)	22 (9.4%)	9 (3.8%)
25-49	674 (57.8%)	71 (6.1%)	158 (13.6%)	30 (2.6%)	38 (3.3%)	20 (1.7%)	8 (0.7%)	0 (0.0%)	3 (0.3%)	92 (7.9%)	72 (6.2%)
50+	56 (45.2%)	3 (2.4%)	18 (14.5%)	2 (1.6%)	4 (3.2%)	0 (0.0%)	2 (1.6%)	0 (0.0%)	0 (0.0%)	17 (13.7%)	22 (17.7%)
Total	861 (55.6%)	84 (5.4%)	214 (13.8%)	41 (2.6%)	48 (3.1%)	25 (1.6%)	11 (0.7%)	21 (1.4%)	5 (0.3%)	134 (8.7%)	104 (6.8%)

$\chi^2 = 1275.929$; df =30; p = .000

Table 9
MSM by Age of Diagnosis
(N = 1548)

	No MSM	MSM
0-12	24 (100.0%)	0 (0.0%)
13-24	88 (37.6%)	146 (62.4%)
24-49	434 (37.2%)	732 (62.8%)
50+	64 (51.6%)	60 (48.4%)
Total	610 (39.4%)	938 (60.6%)

$\chi^2 = 47.291$; df = 3; p = .000

Table 10
Gender by Age of Diagnosis
(N = 1548)

	Female	Male
0-12	12 (50.0%)	12 (50.0%)
13-24	59 (25.2%)	175 (74.8%)
25-49	215 (18.4%)	951 (81.6%)
50+	24 (19.4%)	100 (80.6%)
Total	310 (20.0%)	1238 (80.0%)

$\chi^2 = 19264.784$; df =3; p = .000

Table 11
Race by Age of Diagnosis
(N = 1540)

	White	Black	Other
0-12	16 (66.7%)	8 (33.3%)	0 (0.0%)
13-24	164 (70.4%)	60 (25.8%)	9 (3.9%)
25-49	914 (78.8%)	226 (19.5%)	20 (1.7%)
50+	101 (82.1%)	21 (17.1%)	1 (0.8%)
Total	1195 (77.6%)	315 (20.5%)	30 (1.9%)

$\chi^2 = 14.797$; df =6; p = .022

Table 12
HCV by Age of Diagnosis
(N = 1548)

	No HCV Diagnosis	HCV Diagnosis
0-12	22 (91.7%)	2 (8.3%)
13-24	244 (95.7%)	10 (4.3%)
25-49	1096 (94.0%)	70 (6.0%)
50+	116 (93.5%)	8 (6.5%)
Total	1458 (94.2%)	90 (5.8%)

$\chi^2 = 1.461$; df =3; p = .691

Table 13
IDU by Age of Diagnosis
(N = 1548)

	No IDU	IDU
0-12	24 (100.0%)	0 (0.0%)
13-24	208 (88.9%)	26 (11.1%)
25-49	1019 (87.4%)	147 (12.6%)
50+	113 (91.1%)	11 (8.9%)
Total	1365 (88.1%)	184 (11.9%)

$\chi^2 = 5.027$; df = 3; p = .170

Table 14
Heterosexual Transmission by Age of Diagnosis
(N = 1548)

	No HET	HET
0-12	24 (100.0%)	0 (0.0%)
13-24	184 (78.6%)	50 (21.4%)
25-49	942 (80.8%)	224 (19.2%)
50+	100 (80.6%)	24 (19.4%)
Total	1250 (80.7%)	298 (19.3%)

$\chi^2 = 6.398$; df = 3; p = .094

FIGURES

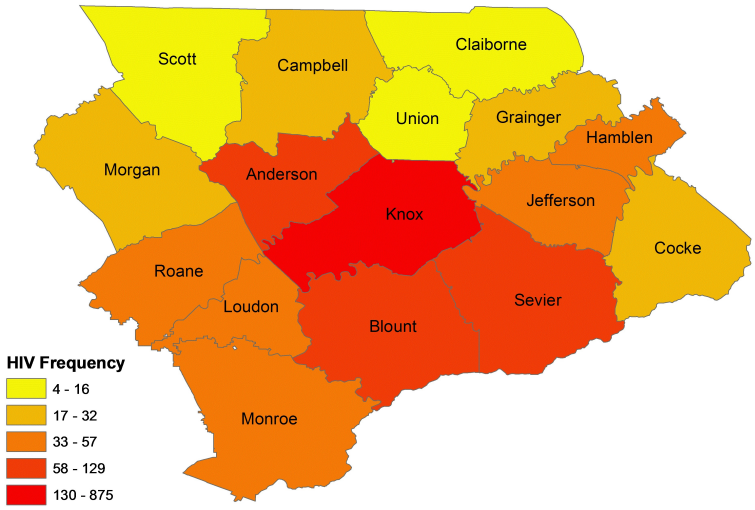

Figure 1. HIV frequencies.

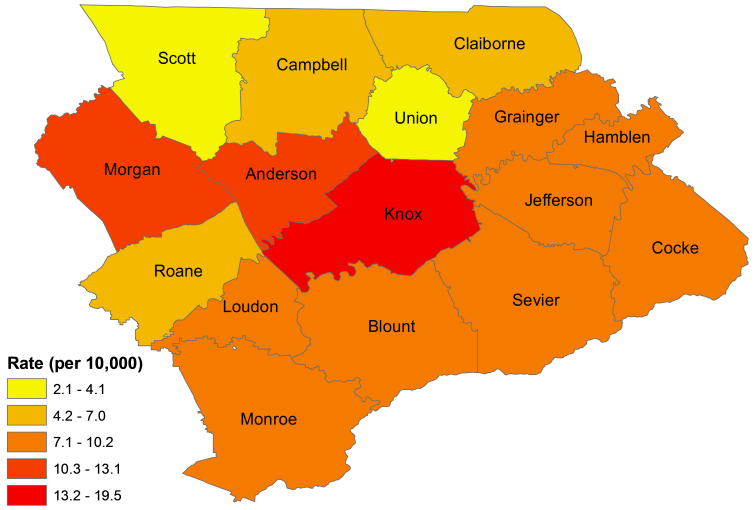

Figure 2. Rate of prevalent HIV cases (per 1,000).

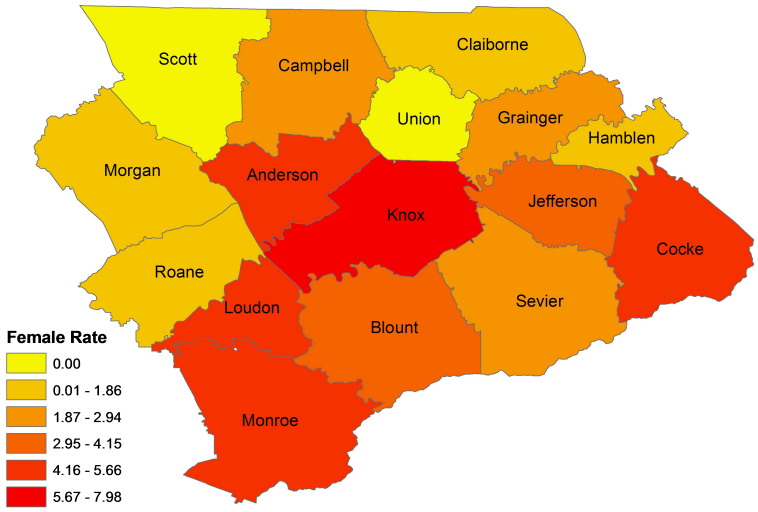

Figure 3. Rate of female HIV diagnoses (per 10,000).

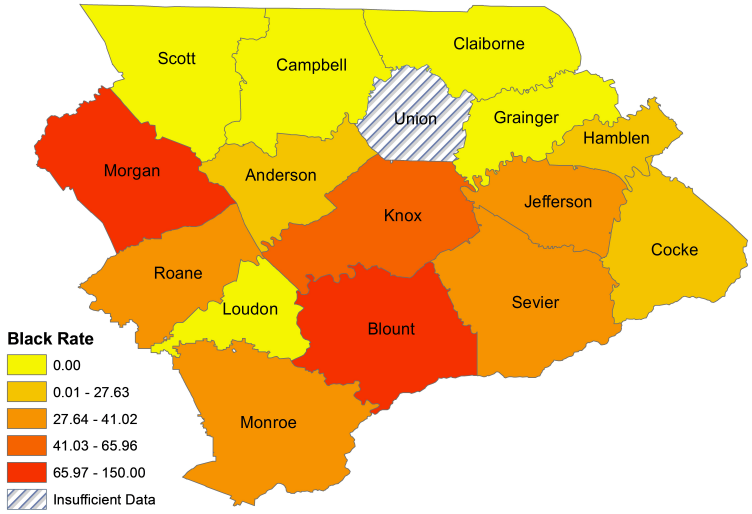

Figure 4. Rate of black HIV diagnoses (per 10,000).

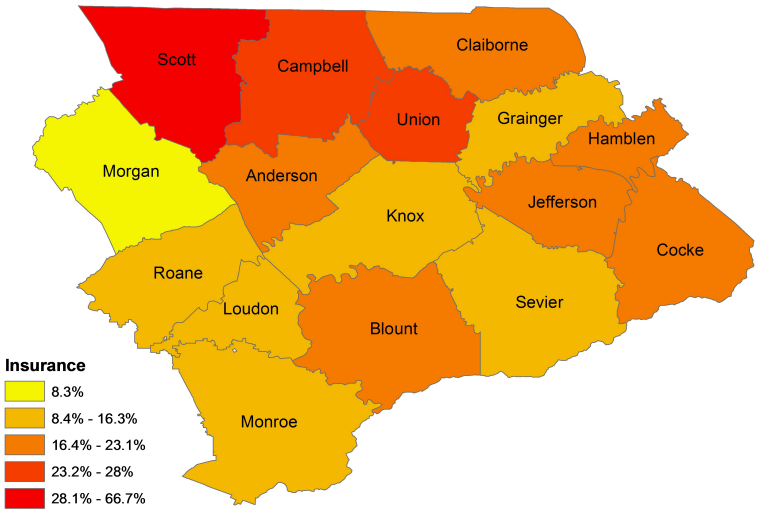

Figure 5. Percentage of HIV diagnoses with insurance.

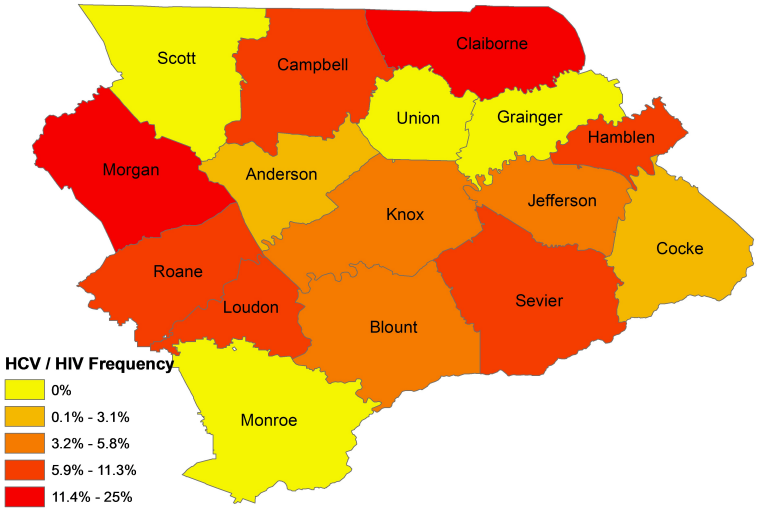

Figure 6. Percentage of HIV diagnoses with HCV coinfection.

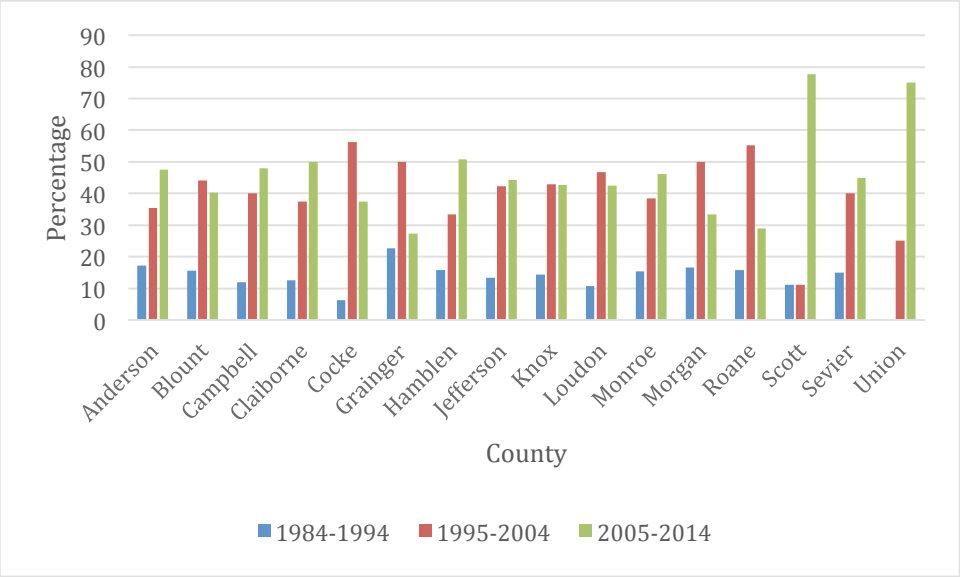

Figure 7. Percentage of HIV diagnoses across time for each county.

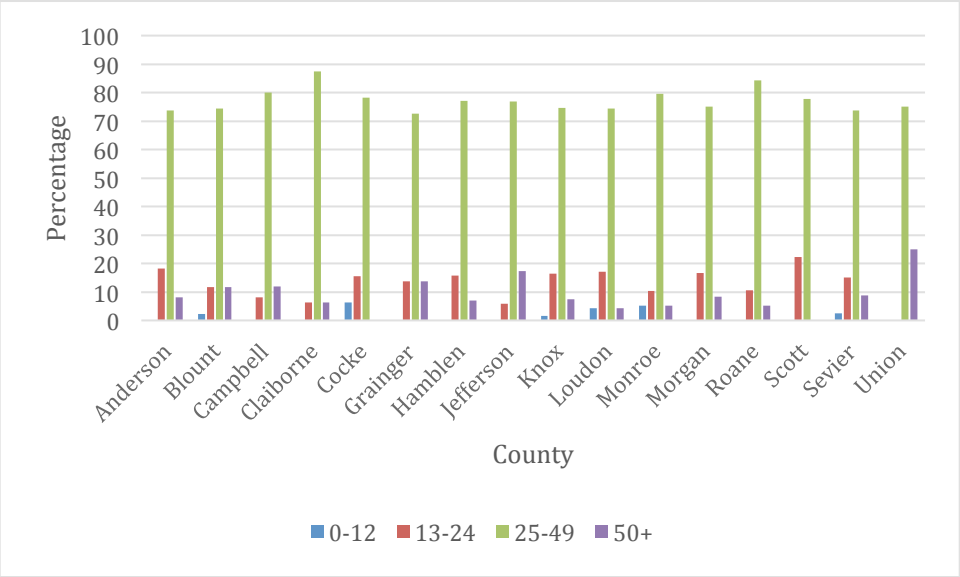

Figure 8. Percentage of HIV diagnoses by age of diagnosis for each county.

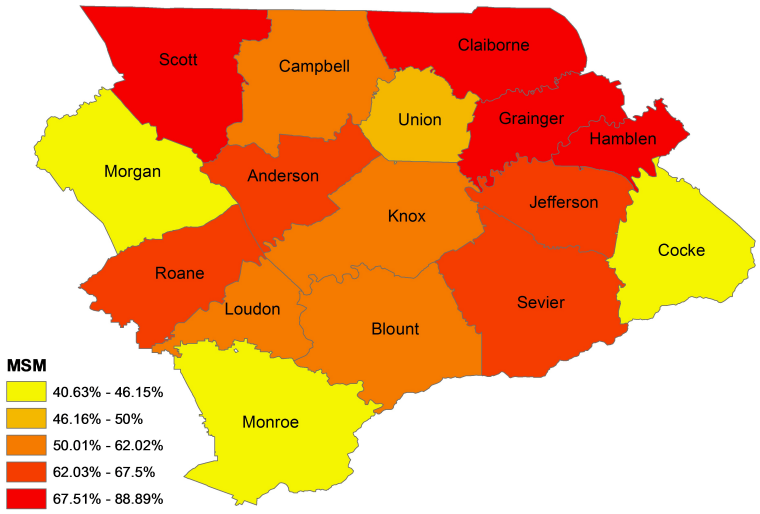

Figure 9. Percentage of HIV by MSM (as full or partial mode of transmission).

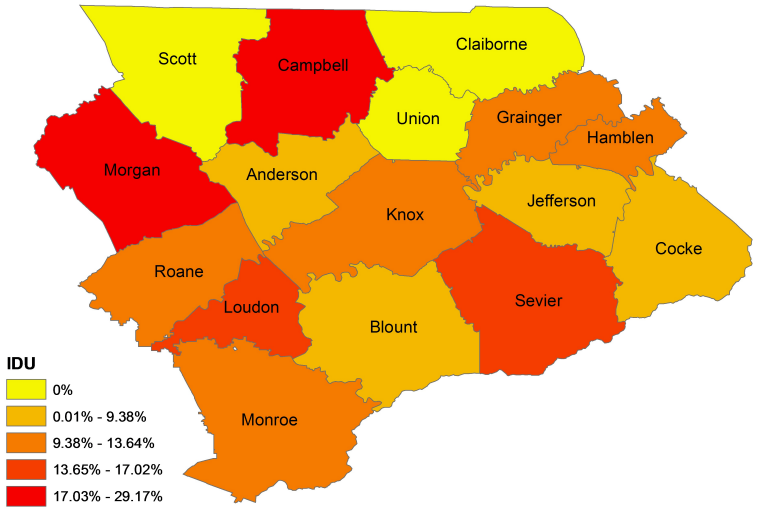

Figure 10. Percentage of HIV by IDU (as full or partial mode of transmission).

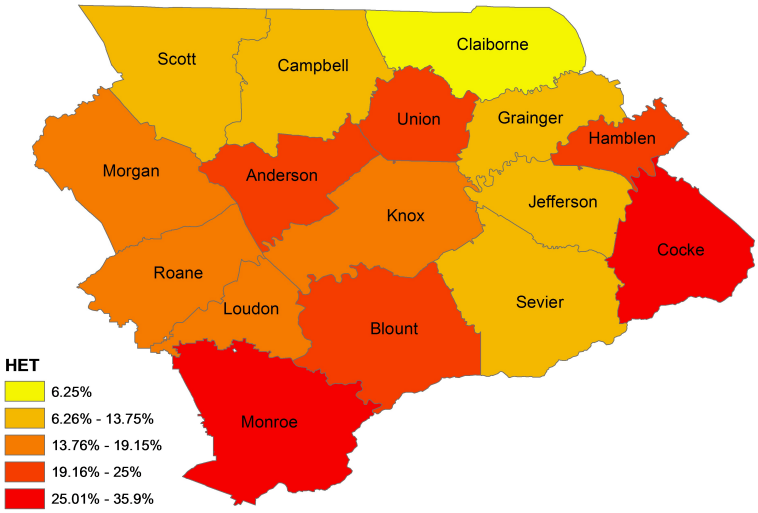

Figure 11. Percentage of HIV by HET (as full or partial mode of transmission).

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