Spatial and socio-behavioral patterns of HIV prevalence in the Democratic Republic of Congo☆

Jane P. Messina [a], Michael Emch [a,*], Jeremie Muwonga [b], Kashamuka Mwandagalirwa [b], Samuel B. Edidi [b], Nicaise Mama [b], Augustin Okenge [b], Steven R. Meshnick [c]

[a] University of North Carolina, Department of Geography and Carolina Population Center, Chapel Hill, NC, United States
[b] Ministry of Health, Democratic Republic of Congo
[c] Department of Epidemiology, University of North Carolina Gillings School of Public Health, Chapel Hill, NC, United States

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ABSTRACT

This study uses a 2007 population-based household survey to examine the individual and community-level factors that increase an individual's risk for HIV infection in the Democratic Republic of Congo (DRC). Using the 2007 DRC Demographic Health Surveillance (DHS) Survey, we use spatial analytical methods to explore sub-regional patterns of HIV infection in the DRC. Geographic coordinates of survey communities are used to map prevalence of HIV infection and explore geographic variables related to HIV risk. Spatial cluster techniques are used to identify hotspots of infection. HIV prevalence is related to individual demographic characteristics and sexual behaviors and community-level factors. We found that the prevalence of HIV within 25 km of an individual's community is an important positive indicator of HIV infection. Distance from a city is negatively associated with HIV infection overall and for women in particular. This study highlights the importance of improved surveillance systems in the DRC and other African countries along with the use of spatial analytical methods to enhance understanding of the determinants of HIV infection and geographic patterns of prevalence, thereby contributing to improved allocation of public health resources in the future.

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Introduction

According to the UNAIDS (2009) *AIDS Epidemic Update*, HIV prevalence in the Democratic Republic of Congo (DRC) is lower overall than most African countries, with a rate of 1.3 percent in adults aged 15–49 compared to 5.2 percent in sub-Saharan Africa (UNAIDS, 2008). However, as many as 94,000 people were estimated to be living with HIV/AIDS in the country in 2007, with women accounting for more than half of the adults estimated to be living with the virus (UNAIDS, 2008). While HIV surveillance data in the DRC are limited, prevalence estimates have suggested much higher HIV rates in the eastern urban regions of the country (WHO, 2005), as well as some higher rates in certain rural areas.

Spatial patterns and geographic drivers of HIV risk

Poverty and economic deprivation have been shown to be complex yet important factors related to HIV transmission, making the study of HIV and AIDS in Africa an area in need of collaboration between natural and social scientists, including geographers (Kalipeni, 2007a). Geography plays an important role in HIV transmission in the Democratic Republic of Congo and other central African countries. While population centers in east Africa are highly interconnected and the HIV epidemic has grown rapidly in this region of the continent, the low-prevalence of the virus in the Democratic Republic of Congo before and after the emergence of the pandemic may be a reflection of the difficulty in travel between major population centers in central Africa (Gray, 2009). Although geographic factors are important indicators of HIV prevalence, there is little current research that uses spatial analytical techniques to study local heterogeneity of HIV prevalence rates in Africa. A 2002 review by Tanser and Leseuer of the application of Geographic Information Systems (GIS) to public health problems in Africa found only one study which incorporated GIS in analyzing factors related to HIV prevalence. This study (Tanser, Lesueur, Solarsh, & Wilkinson, 2000) found a significant correlation between

HIV prevalence rates in South Africa and proximity of homesteads to primary or secondary roads using HIV data obtained from antenatal care clinics. Since 2002, the number of national-level studies using spatial analytical methodologies to study HIV prevalence has increased (Busgeeth & Rivett, 2004; Chamla et al., 2007, Kalipeni and Zulu 2008, Tanser, Barnighausen, Cooke, & Newell, 2009; Vanmeulebrouk, Rivett, Ricketts, & Loudon, 2008); however, to date no detailed spatial studies have been published on HIV prevalence in the DRC.

Past studies of HIV transmission in African countries have shown prevalence to be associated with geographic factors including population mobility, migrant labor routes, and proximity to urban high-transmission areas (Amat-Roze, 1993; Arroyo et al., 2005, 2006; Coffee, Lurie, & Garnett, 2007; Coffee et al., 2005; Karim, 2009; Remy, 1993; Serwadda et al., 1992). Studies that map the geographic distribution of populations at greater risk of infection, such as non-circumcised males and commercial sex workers, have been important to our understanding spatial heterogeneity in rates of HIV prevalence (Obbo, 1993; Webb, 1994). Unfortunately, the lack of precise spatially-referenced data in many African countries often hinders detailed geographic studies of HIV prevalence.

Socio-behavioral factors and HIV risk

While poverty has been shown to be significantly related to risky sexual outcomes (Dodoo, 2007; Kalipeni, 2007b; Masanjala, 2007), the urban poor have been found to be more likely to be infected with HIV than rural poor in African countries such as Kenya, due to a greater incidence of multiple sexual partnerships in impoverished urban areas. High unemployment, financial insecurity, unstable wages, and a social context which promotes prostitution may explain such disparities across economic classes (Dodoo, 2007).

It cannot be ignored that the DRC has been in and out of war since the beginning of the HIV epidemic. Persistent conflict has led to the displacement of large numbers of refugees within central African countries, eliminating much of what little employment existed and placing an even greater demand on minimal health infrastructure. The combination of chaos, poverty, population displacement, and sexual violence would seem to provide a likely setting for high rates of HIV transmission; however, we have discussed that the prevalence of HIV in the DRC is low in comparison to most sub-Saharan African countries. Surprisingly, most studies to date have found little or no relationship between HIV and conflict. A 2007 Lancet review article (Spiegel et al., 2007) found no relationship between seroprevalence and conflict. In this review, 65 studies in seven countries compared HIV seroprevalence before and after conflict, and in conflict areas or refugee camps compared to peaceful neighboring areas. Another study found no effect of widespread rape on HIV prevalence. This study suggested that even when 15% of women were raped by assailants with high HIV prevalence, overall HIV seroprevalence would only increase by 0.023% (Anema, Joffres, Mills, & Spiegel, 2008). However, two studies from the DRC suggest that violence is indeed associated with an increased HIV seroprevalence, with increased HIV prevalence found among refugees compared to the general population (Kim et al., 2009; Mulanga et al., 2004).

Also relevant to this study is recent research indicating that in many African countries, HIV prevalence is higher in women than in men (Berkley, 1990; Glynn, 2001; Laga, Matendo, & Buve, 2008; MacPhail, 2002; UNAIDS, 2008, 2009; Zierler and Krieger 1997). While it has been argued that gender norms and expectations have contributed to increased risk and societal vulnerability to HIV (Masanjala, 2007), Glynn (2001) found that the gender discrepancy

in HIV existed in Kenyan and Zambian adults despite age at sexual debut being similar in both genders and number of sexual partners being higher in men in some cases. Furthermore, they found that prevalence was very high even among women reporting only one lifetime sexual partner and few instances of sexual intercourse. Therefore, it is possible that these seemingly important behavioral factors may not explain the differences between HIV prevalence in men and women.

The gender disparity in HIV prevalence in many African countries is likely due in greater part, then, to biological factors such as the greater ease with which HIV is spread from men to women than vice versa, especially during cases of forced sex or first female intercourse. Greater prevalence of other sexually transmitted diseases such as the herpes simplex in women may further increase their biological risk of HIV infection (Glynn, 2001, Laga, 2001). It has been argued, however, that this vulnerability to infection is worsened for women by social inequalities (Kalipeni, 2007a,, 2008).

Gaps in recent literature

HIV prevalence in the DRC and many other African countries has often been estimated using blood samples drawn from pregnant women in antenatal clinics. While these data have been shown to provide proximate estimates of prevalence in the overall population of women and men (Pisani, Schwartländer, Cherney, & Winter, 2000), there are obvious limitations in that these samples do not include women who are either not pregnant or do not attend antenatal care clinics, nor do they include men. Furthermore, pregnant women have been found to be at increased risk for new HIV infection (Gray et al., 2005), and knowledge of HIV status may also reduce a woman's fertility choices. Another important limitation to sentinel surveillance systems for HIV is that almost no information is collected about the demographic or behavioral characteristics of the individual women, nor is the geographic location of their place of residence. While broad regional estimates of prevalence may be possible from this type of data, its limitations present important obstacles when attempting to analyze the socio-demographic, behavioral and geographic determinants of HIV infection.

The current study used a 2007 population-based household survey of the DRC to examine the individual and community-level factors that increase an individual's risk for HIV infection. Geographic coordinates of the survey communities were used to map prevalence of HIV infection in the country and compute rates for areas surrounding an individual's community, as well as to explore a number of additional geographic variables thought to be related to HIV risk. These were explored in conjunction with several demographic and behavioral characteristics extracted from the survey. Improved surveillance systems in the DRC and other African countries have the potential to greatly enhance understanding of the determinants of HIV infection as well as the spatial patterns of prevalence, therefore contributing to improved allocation of public health resources in the future.

Data and methods

The 2007 DRC Demographic Health Surveillance (DHS) survey was a population-based, nationally representative survey linking individual HIV test results to that individual's responses to an array of socio-demographic and behavioral characteristics. With the exception of Kinshasa which is the country's densely-populated capital, each of the country's eleven provinces was divided into three strata: major cities, towns, and rural areas, with a total of 34 enumeration areas created. The basis for these areas was the 1984 DRC census which contained a complete list of neighborhoods in