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Assessing the spatial nonstationarity in relationship between local patterns of HIV infections and the covariates in South Africa: A geographically weighted regression analysis

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ABSTRACT

Beyond the structural drivers such as distance from the road, rural/urban divide or demographic profiles, not much is known about the spatial relationship between HIV and social covariates. Spatial relations between social covariates and HIV infection of persons above 15 years were explored and mapped using geographically weighted regression model using data from a national HIV household survey conducted in 2008 and comprising 23 369 individuals from approximately 1000 enumeration areas that were randomly selected from the national census. The maps show spatial non-stationarity in relationship between local patterns of HIV prevalence and the social covariates across South Africa. The high prevalence districts have very homogeneous population defined by the following characteristics: Black origin, unfavorable sex ratio (high proportion of females), low socioeconomic status, being single or low marriage rates, multiple sexual partners and intergenerational sex. Markedly, intergenerational sex compounds the risk of acquiring HIV infection for females in poor districts. Identification of key social drivers of HIV and how they vary from location to location can help to effectively guide and focus intervention programs to areas of particular need.

1. Introduction

South Africa is at the epicenter of the HIV and AIDS epidemic, with more than 6.4 million person living with HIV (Shisana et al. 2014), and overall HIV prevalence estimate of 29.5% among antenatal women (Department of Health 2013). The HIV epidemic in South Africa is heterogeneous, varying largely by province. It is highest in the provinces of KwaZulu- Natal (16.9%) and Mpumalanga (14.1%); and lowest in Western Cape (5.8%) and Northern Cape (7.4%) (Shisana et al. 2014). This means that the same covariates cause different HIV responses across the country.

Efforts to explore the relationship between HIV prevalence and covariates is mostly at national or provincial levels using global regression models (Wabiri & Taffa 2013; Lurie et al. 2003; Wand & Ramjee 2010; Fox 2010). Such models tend to mask important local-area variation and cause misinterpretation of the true covariates contributing to underlying spatial patterns (Tukey 1988). Localized spatial models are crucial in understanding the relationship between local patterns of HIV prevalence and the covariates. This is critical to prevention efforts (Weir et al. 2003) especially in resource poor settings (Auerbach et al. 2006; Maticka-tyndale and Brouillard-coyle 2006; Michielsen et al. 2010).

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The modeling of local patterns of HIV infections at lower levels than the province include works of Tanser et al. (2009) in KwaZulu Natal, who concluded that clustering of infections was along the main roads and that they decreased further away from the main roads. Two studies, one by the Department of Health (2011) looking at pregnant women aged 15 to 49 years attending antenatal clinics in two districts in KwaZulu Natal, and one by Bärnighausen et al. (2008), reported high cases of HIV incidence in rural South Africa. Kleinschmidt et al. (2007) study focused on youths 15–24 years and reported considerable variation in HIV prevalence within provinces, which was associated with ethnicity, urban status, and unemployment.

Beyond the structural drivers such as distance from the road, rural/urban divide or demographic profiles, not much is known about the nature of spatial relationship between HIV and social covariates such as intergenerational sex, marital status, sexual partnership and condom use. Still unavailable is a national spatial distribution of HIV infection prevalence estimates by district derived from the general population.

The aim of this paper is to investigate levels of and reasons for observed local patterns of HIV infections in South Africa using the 2008 national population-based household survey (Shisana et al 2009). The objectives of the paper are to

(1) assess the spatial relationship between local patterns of HIV infections and the social covariates in South Africa, in addition to well know demographic covariates and,
(2) investigate the association between local patterns of HIV infections and the public health care utilization

2. Materials and methods

2.1. Survey sampling, field and laboratory procedures

This paper is a sub-analysis of the 2008 South African National HIV prevalence, Incidence, Behavior and Communication Survey (Shisana et al. 2009). This cross-sectional population-based household survey was conducted from May 2008 to March 2009. The survey design applied multistage stratified sampling by: province; locality (urban formal, urban informal, rural formal including commercial farms, and rural informal or tribal areas); and predominant racial groups. Sampling frame was based on enumerator areas (EA) used in the national census, updated to reflect changes in the socio-demographic profile of the country since 2001. Full details of the survey methodology, including sample weighting, fieldwork procedures and quality control measures, are described elsewhere (Shisana et al. 2009; Rehle et al. 2010).

In total, 1000 EAs were selected from a database of 86,000 EAs as the primary sampling units; 15 households within each EA constituted the secondary sampling unit (15,000 households); and four persons in each household were eligible; one in each age group (0–1, 2–11, 12–14, 15more years) formed the final sampling unit. If a household contained two or more persons in an age category, a Kish table was used for selecting one person in each age group per household (Kish 1949). Any person who slept in the household on the night preceding the survey (including visitors) was considered a household member. All household members in the selected households were eligible to participate, including those living in hostels, but those inhabiting educational institutions, old-age homes, hospitals and uniformed-service barracks, as well as homeless people, were excluded.

Study activities were approved by the Human Science's Research Council's Research Ethics Committee and the Human Subjects Review from the Centre for Disease Control and Prevention's Global AIDS Programme. Dried blood spot (DBS) specimens were used for HIV antibody testing, with testing following an algorithm of three HIV enzyme immunoassays (Shisana et al. 2009).

2.2. Study measures

The "District Municipality" in South Africa is used as the spatial mapping unit in this study. There were a total of 52 District Municipalities (Fig. 1). The district Health System is also the basic channel through which the delivery of Primary Health Care is undertaken in South Africa (Monticelli et al. 2010). It therefore made sense to do analysis at district level as opposed to the local municipalities.

Study measures constitute survey weighted proportions of female population; Blacks population; urban formal and urban informal population; non-regular condom users; single population; those having older (>5 years); and those aged 25 to 49 years, aggregated at district level. Details of how individual weights were calculated and applied to obtain the study measures at district level are shown in are shown in Appendix, page 17.

The Social Economic Quintiles (SEQ) measures were derived from the deprivation index (DI) – a measure of relative deprivation of populations across districts within South Africa, obtained from a set of demographic and socio-economic variables[1] in the 2007 Community Survey and the 2005 and 2006 General Household Surveys (Day et al. 2012). Based on the DI, the 52 districts are ranked into SEQ. each containing 20% of all districts. The districts that fall into quintile 5 are the top 20% least deprived (best off) districts. The ten districts in quintile 1 contain people with the lowest socio-economic status and are the most deprived (worst off).

The weighted HIV prevalence in each district forms the dependent variable.

[1] Proportion of (a) the district's population that are children below the age of five; (b) the district's population that are black Africans; (c) household heads in the district that are females; (d) household heads in the district that has no formal education; (e) working-age population within the district that is unemployed (not working, whether looking for work or not – the official definition of unemployment in South Africa); (f) the district's population that lives in a traditional dwelling, informal shack or tent; (g) the district's population that has no piped water in their house or on site; (h) the district's population that has a pit or bucket toilet or no form of toilet; (i) the district's population that does not have access to electricity, gas or solar power for lighting, heating or cooking.