The HIV epidemic in sub-Saharan Africa: From social networks to maps

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Core groups (super spreaders): members that have high levels of risk behavior
The study of sexually transmitted infections such as **HIV** has focused on **social space**

**Sexual networks**: groups of persons connected to one another sexually

**Characteristics**:  
- Number of partners (links)  
- Number of sexual contacts  
- Concurrent relationships  
- Condom use

*Figure by Roel Bakker, Erasmus MC, Rotterdam (in An Introduction to Infectious Disease Modelling, Vynnycky and Whithe, 2014)*
Concentrated epidemic
Concentrated epidemic

High-risk groups
Generalized epidemic
Sub-Saharan Africa (SSA) has by far the largest HIV epidemic in the world, with an estimated **25 million infected individuals** over the past two decades.
• The ‘**Know your epidemic, know your response**’, a Joint United Nation Programme on HIV/AIDS (UNAIDS), has become one of the first calls to modify the current strategy by recognition of the fact that **there is not a single global HIV epidemic**

• This strategy highlighted the significant role that **geographical space** could play in the identification of populations at **higher risk**
Estimated percentage of adults who are HIV+, 2003

Source: UNAIDS, 2004
Geographical hotspots of HIV
Spatial distribution of HIV

HIV Prevalence

- > 10%
- < 2%
Why do we need to know the spatial distribution of HIV?
Spatial risk of HIV infection

HIV Prevalence

> 10%

< 2%
What is the contribution of the HIV hotspot in the transmission network?
We improve population health by conducting high quality research focused on eliminating new HIV infections, reducing TB transmission and improving local health systems.

DATA REPOSITORY

Since January 2000, the Africa Centre For Population Health has built up an extensive longitudinal database of demographic, social, medical and economic information about the members of its Demographic Surveillance Area, which is situated in a rural area of northern KwaZulu-Natal. It has developed from this database, the following
The site has collected socio-demographic information on a population of 87,000 participants within a circumscribed geographic area (438 km²) for over a decade.
Data collection

- Fieldworker deployment
- Map-based homestead identification
- Paper-based interview
- Tracker deployment
- GPS-based homestead identification
- Dry Blood Spot (DBS) specimen collection
All participants under surveillance are geo-located to their respective homesteads of residence (accuracy <2m)
HIV prevalence

- >20%
- <10%

HIV incidence

- >5
- <2
HIV prevalence

>20%
<10%

Prevalence of detectable viremia

> 15%
0%
• HIV hotspot sustains high levels of virus transmission
HIV prevalence

- Contribution of the HIV hotspot in the transmission network
Phylogeographical approach to reveal the geography of HIV transmission networks
Three microsimulation models were generated to assess the association between the HIV hotspot and HIV transmission links

• **Model 1.** Epicenter model

• **Model 2.** Distance decay link formation model

• **Model 3.** Random links formation model
• **Model 1.** Epicenter model
• **Model 2.** Distance decay link formation model
• **Model 2.** Distance decay link formation model
• **Model 3.** Random links formation model
- **Model 1. Epicenter model**
• **Model 2.** Distance decay link formation model
• **Model 3. Random links formation model**

![Diagram showing model 3 with a map and bar chart comparing data and model 3 results for percentage of links within, outside, and crossing hotspots.]
General Conclusions

• HIV hotspots evidence the location of populations at high risk if HIV infection

• These hotspots might play a key role in the HIV transmission network and could substantially contribute to the dispersion of the infection

• Disrupting the transmission network using geographically targeted interventions could be an effective strategy aimed to optimize resources and maximize the impact on the epidemic in SSA