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Using spatial analysis for estimation of the stage of HIV epidemic

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Objective
To investigate the utility of spatial analysis in the tracking of the stages of the HIV epidemic at an administrative territory level, using the Odessa region, Ukraine, as an example.

Introduction
Detection of the signs of HIV epidemic transition from concentrated to generalized stage is an important issue for many countries including Ukraine. Objective and timely detection of the generalization of HIV epidemic is a significant factor for the development and implementation of appropriate preventive programs. As an additional method for estimating HIV epidemic stage, the spatial analysis of the reported new HIV cases among injection drug users (IDU) and other populations (due to sexual way of transmission) has been recommended.

For studying new HIV cases in small societies, relative risk (RR) rates are preferred over incidence indicators. Spatial clustering based on the calculation of RR rates allows us to locate the high-risk areas of HIV infection with greater accuracy.

In our opinion, in the process of epidemic generalization, the spatial divergence of epidemic will be observed as well. In particular, clusters with high RR of sexual HIV transmission independent from the clusters with high RR of injection HIV transmission may appear.

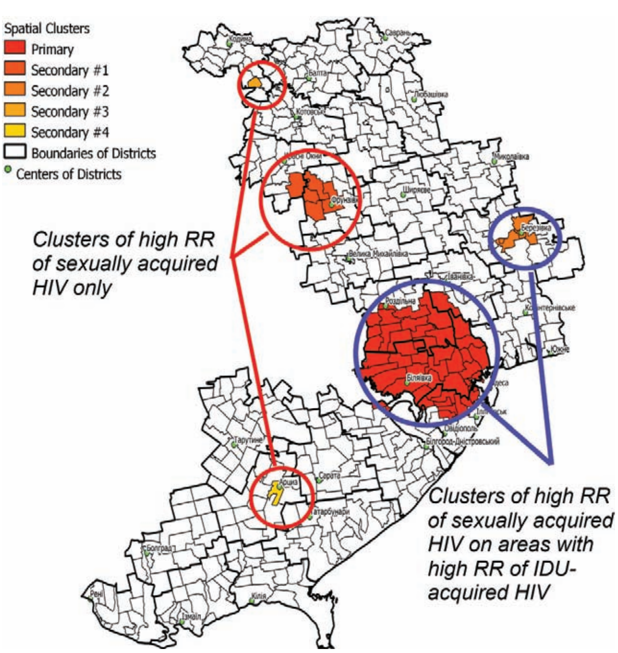

Fig. 1. Spatial clusters of high RR of sexual acquired HIV in the Odessa region in 2005–2009.

Methods
We used spatial clustering based on reported HIV cases acquired through IDU and sexual transmission from 1994 to 2009 in the smallest administrative units (called Radas) in the rural territory of the Odessa region, Ukraine. For the formal spatial clustering, we used Kulldolf Spatial Statistics, realized in the SatScan program. Clustering was conducted by the Poisson model. We used the circle window and set the cluster size limit empirically at 15% of the at-risk population. The study was done in clusters with high RR.

Visualization was carried out on QuantumGIS.

Results
With clustering, the HIV incidence due to IDU and sexual intercourse were mostly identical in the 1994–1999 and 2000–2004 periods. However, three spatial clusters of sexually acquired HIV emerged in the 2005–2009 period ($RR = 3.44$, $p = 0.0005$; $RR = 10.60$, $p = 0.011$; $RR = 2.18$, $p = 0.0265$), which did not correspond to an increased RR of IDU-acquired HIV (see Fig. 1).

Proportion of Radas, simultaneously included in the clusters of both types of HIV transmission, decreased from 64.58% in 2000–2004 to 48.33% in 2005–2009.

To test the effectiveness of the method, we compared the number of Radas where HIV cases were registered due to sexual transmission only and were not detected due to IDU. In the 2005–2009 period, we observed an increase in the number of Radas reporting sexually acquired HIV cases but not IDU-acquired HIV cases.

Conclusions
The spatial clustering of the HIV epidemic in the rural areas of the Odessa region showed a divergence in the spatial distribution between IDU and sexually transmitted HIV. We believe this finding may indicate the generalization tendencies of HIV epidemic. Our hypothesis has been supported by other epidemiological characteristics, such as: increase in number of sexual HIV cases and their proportion in the total number of HIV cases; increase in proportion of Radas reporting sexually acquired HIV cases but not IDU-acquired HIV cases; increase in the proportion of sexual HIV cases reported in these Radas; HIV seroprevalence among pregnant women in the region accounted in average to 0.9–1.1%.

To estimate HIV epidemic stage, additional methods of epidemiological analysis like spatial analysis of morbidity can be used.

Keywords
HIV epidemic; spatial analysis; GIS

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