Use of mobile phone data in HIV epidemic control

UNAIDS' Global AIDS update states that efforts to increase HIV prevention are effective when "resources are strategically targeted where they can have the maximum impact".[1] Such targeting is implemented by prioritising geographical areas where people are at the highest risk of HIV, and it is most frequently implemented at the administrative level; however, it does not consider mobility, although individuals cross administrative boundaries.

Mobile phone data can be used to identify circular travel patterns and to reveal hidden spatial structures in populations: to detect metacommunities. A metacommunity is a subset of communities that are more tightly linked to each other (due to individuals travelling among them) than to other communities; metacommunities are loosely linked (through travel) to other metacommunities. We propose that a metacommunity be considered as a single social-sexual community (ie, a group of individuals who have the majority of their social and sexual contacts within the group), and that a linked network of social-sexual communities can be used to design geographical targeting strategies for controlling HIV. We have applied these ideas to Namibia.

Namibia has a generalised HIV epidemic: 12·6% of adults live with the virus.[2] To reveal the mobility network and identify social-sexual communities, we used mobile phone data from Namibia; these data have previously been used to analyse travel patterns to understand malaria dynamics[3] and reveal HIV risk networks.[4] The data are records from 9 billion calls and texts over a 12-month period.

We used methods from network science in our analysis.[5] These methods have been used to find metacommunities in mobility networks in Cote d'Ivoire,[6] France,[6] Great Britain,[7] and the USA.[8] Namibia is geographically subdivided into eight social-sexual communities (figure). These communities vary in terms of geographical area, the number of constituencies they contain (2–33), urbanicity, and size (15 000–650 000 individuals; figure A, B).

Social-sexual communities are linked by bridge constituencies (defined as having substantial mobility ties with a social-sexual community other than that to which they belong). Two types of bridges exist: short bridges connect spatially contiguous constituencies, and long bridges connect non-contiguous constituencies. Notably, the capital of Namibia (Windhoek) is a long-bridge constituency connecting six social-sexual communities. The network diagram (figure C) shows the constituencies clustered into the eight social-sexual communities, with lines between and across the communities.

Considering a population as a network of linked social-sexual communities provides a new understanding of generalised HIV epidemics as connected subepidemics. Each subepidemic is associated with a specific social-sexual community, and subepidemics are connected to each other in specific geographical locations (at the bridge constituencies). Identifying social-sexual communities might also help to identify the most important type of transmission occurring—for example, if the community contains an urban centre and rural villages, this suggests that urban-to-rural and rural-to-urban transmission is important.

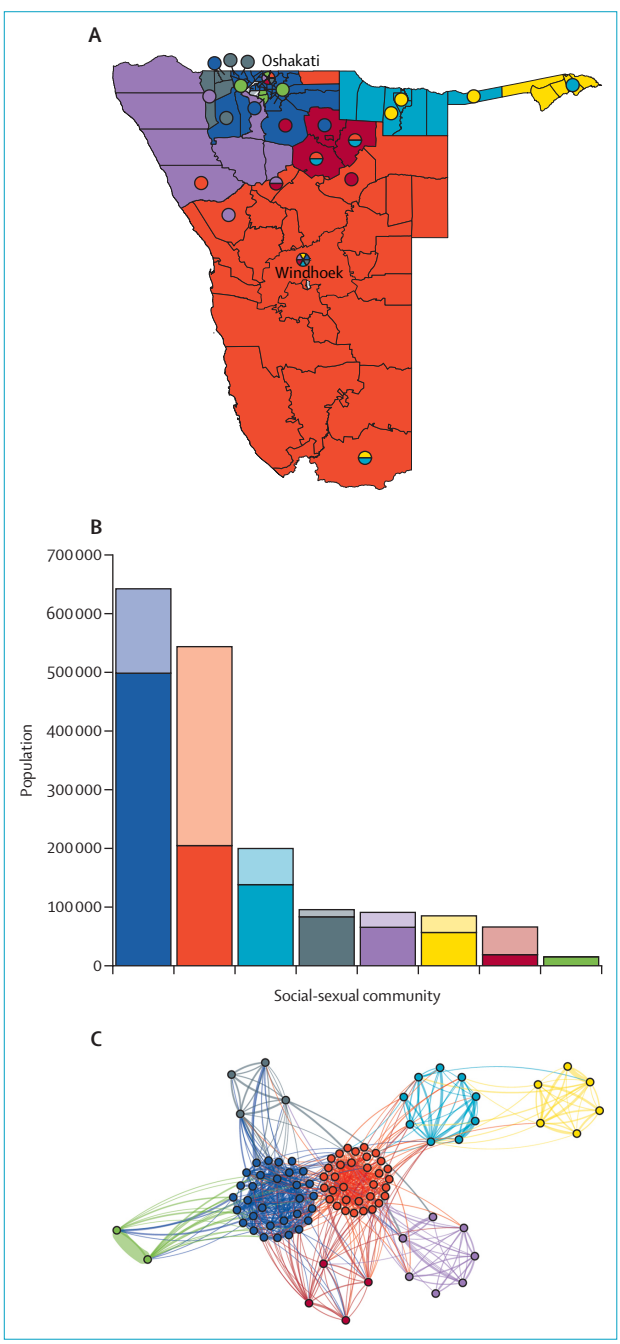

***Figure*: Social-sexual communities in Namibia**
(A) Namibia is shown partitioned into eight social–sexual communities. Each constituency is colour-coded to show its membership in a specific social–sexual community. Bridge constituencies are denoted with circles; the colour within each circle is the colour of the linked social-sexual community. For example, the red community containing a purple circle shows the geographical location of the constituency that is a bridge to the purple community. This indicates that many people who live in the purple community spend time in the bridge constituency within the red community. (B) Population size of each social–sexual community by urban or rural status (light colours represent urban areas and dark colours represent rural areas). (C) Network diagram showing all constituencies (circles; colour-coded by social-sexual community as in panels A and B). Lines show the links within and across communities.

We propose social-sexual communities be targeted for interventions and treatment programmes, rather than geographical areas delimited by arbitrary administrative boundaries. The spatial scale of the targeting strategy should reflect the size of the geographical area each community occupies. The identification of network bridges will show which subepidemics are linked; this approach could be used to determine where it would be most beneficial to implement synchronised strategies. Bridges should be targeted to reduce the probability of source–sink dynamics occurring;[9] these dynamics enable a subepidemic in one area to maintain a subepidemic in another area where transmission is too low to be self-sustaining. Additionally, targeting bridges could potentially prevent the movement of new strains between two or more subepidemics.

To date, distribution strategies of HIV prevention modalities in countries with generalised epidemics have considered geographical location, but exclusively in terms of administrative boundaries. The role of human mobility in shaping connected communities across such boundaries, and the impact of mobility as a driver of HIV risk acquisition, has been ignored. We recommend that, to design more effective geographically targeted preventative interventions, large-scale mobility data should be collected and social-sexual communities should be identified.

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