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Short Communication: Prioritizing Communities for HIV Prevention in sub-Saharan Africa

Till Bärnighausen,[1,2] Frank Tanser,[2] Timothy Hallett,[3] and Marie-Louise Newell[2,3]

Abstract

HIV prevalence is the most commonly used measure to prioritize communities for HIV prevention. We show that data on two HIV infection stages (early vs. nonearly and late vs. nonlate) allow estimation of two better measures of prevention need: HIV incidence (for prevention of HIV acquisition) and expected probability of HIV transmission in unprotected sex acts between HIV-infected community members and susceptible individuals (for prevention of HIV transmission). The three ranking schemes—by prevalence, incidence, and transmission probability—lead to significantly different community rank orders. Disease stage information should be collected in HIV surveys.

Following the recent worldwide recession, prioritization of communities for HIV interventions is likely to become increasingly important as budgets for HIV are expected to decrease.[1] In addition, it seems unlikely that universal antiretroviral treatment coverage can be achieved and maintained, unless the rate of new HIV infections is significantly reduced.[2] Ranking is a common approach to prioritize communities for HIV prevention[3] and HIV prevalence is the most commonly used measure for such ranking.[4] The dominance of prevalence as a measure for prioritization for HIV prevention can be explained by the fact that it is the most widely available data on HIV, for instance, from antenatal care surveillance[5] or Demographic and Health Surveys (DHS).[6] However, although prevalence is a good measure for prioritization of HIV care needed by all HIV-infected individuals (e.g., tuberculosis screening), there are better measures of prevention need: the rate of new infections among susceptible community members (HIV incidence) for prevention of HIV acquisition and the expected probability of HIV transmission in a sex act between an HIV-infected community member and a susceptible individual for prevention of HIV transmission through "positive prevention." Interventions to decrease HIV acquisition include male circumcision[7] and behavior change in HIV-uninfected individuals. "Positive prevention," i.e., targeting HIV-infected individuals to reduce HIV transmission, has recently been advocated to curb the HIV epidemic in sub-Saharan Africa.[8,9] It includes disclosure of positive HIV status, behavior change in HIV-infected individuals, and antiretroviral therapy.[8]

We used data from a large HIV surveillance in the Hlabisa subdistrict, rural South Africa, to investigate the differences in the prioritization of geographic communities by prevalence, incidence, and transmission probabilities.[10,11] The rate of new HIV infections in this area remains high.[12] We first located eligible individuals (all women aged 15–49 years old and men aged 15–54 years old who were resident in the surveillance area in 2003/2004 and participated in the HIV surveillance) in 20 traditional Zulu communities, *Izigodi*, where they lived at the time of the HIV test in the surveillance, using a geographic information system.[10] *Izigodi* are a meaningful concept of community, because they are the smallest unit of traditional Zulu leadership and community entry for HIV interventions would likely need to be negotiated with the local *Isigodi* chief, the *Induna*.

To measure community incidence and transmission probabilities, only two binary variables are necessary in addition to HIV status: early vs. nonearly and late vs. nonlate stage HIV infection. In each community, we measured the proportion of individuals with early-stage infection with the BED IgG-Capture Enzyme Immunoassay (BED assay), a test for recent HIV infection (TRI), which was previously validated in the surveillance area.[13] The BED assay defines early-stage infection as 153 days after seroconversion, i.e., approximately half a year after HIV infection.[14] We adjusted the proportion of individuals with early-stage infection for the long-term false-positive ratio of the BED assay in this community (1.69%).[13] We then used the BED assay information to estimate HIV incidence following a locally

[1]Department of Global Health and Population, Harvard School of Public Health, Boston, Massachusetts.
[2]Africa Centre for Health and Population Studies, University of KwaZulu-Natal, KwaZulu-Natal, South Africa.
[3]Department of Infectious Disease Epidemiology, Imperial College, London, UK.

Table 1. Community Prevalence, Incidence, Transmission Probability, Rankings, and Rank Order Differences[a]

Community	n	*Prevalence (%)*	*Incidence (per 100 person-years)*	*Expected transmission probability (per unprotected sex act)*	*Ranking based on prevalence*	*Ranking based on incidence*	*Ranking based on transmission probability*	*Difference in rank order based on incidence vs. prevalence*	*Difference in rank order based on transmission probability vs. prevalence*
A	1796	31.18 (1.09)	5.01 (1.18)	0.0403 (0.0028)	1	3	2	2	1
B	1249	28.42 (1.28)	5.43 (1.37)	0.0393 (0.0033)	2	2	3	0	1
C	212	26.42 (3.03)	10.97 (4.47)	0.0434 (0.0092)	3	1	1	−2	−2
D	291	23.71 (2.49)	4.19 (2.44)	0.0266 (0.0055)	4	6	4	2	0
E	817	21.3 (1.43)	1.91 (1.03)	0.0237 (0.0029)	5	15	8	10	3
F	556	20.68 (1.72)	1.68 (1.24)	0.0242 (0.0038)	6	17	7	11	1
G	698	19.77 (1.51)	2.89 (1.22)	0.0227 (0.0032)	7	11	10	4	3
H	921	19.00 (1.29)	4.24 (1.31)	0.0263 (0.0033)	8	5	5	−3	−3
I	395	18.48 (1.95)	0.58 (1.05)	0.0181 (0.0034)	9	19	18	10	9
J	792	18.43 (1.38)	2.08 (1.04)	0.0205 (0.0028)	10	13	12	3	2
K	1070	17.85 (1.17)	1.87 (0.88)	0.0193 (0.0023)	11	16	16	5	5
L	407	17.44 (1.88)	2.02 (1.45)	0.0202 (0.0040)	12	14	13	2	1
M	237	17.3 (2.46)	4.09 (2.43)	0.0248 (0.0064)	13	7	6	−6	−7
N	311	16.08 (2.08)	4.79 (2.29)	0.0215 (0.0052)	14	4	11	−10	−3
O	144	15.97 (3.05)	1.23 (2.09)	0.014 (0.0050)	15	18	20	3	5
P	722	15.93 (1.36)	0.42 (0.70)	0.0163 (0.0025)	16	20	19	4	3
Q	602	14.95 (1.45)	2.6 (1.26)	0.0194 (0.0035)	17	12	14	−5	−3
R	134	14.93 (3.08)	3.54 (2.88)	0.0181 (0.0068)	18	8	17	−10	−1
S	219	14.16 (2.36)	3.20 (2.21)	0.0235 (0.0068)	19	10	9	−9	−10
T	213	14.08 (2.38)	3.31 (2.28)	0.0194 (0.0060)	20	9	15	−11	−5

[a]Standard errors are shown in parentheses. Standard errors of incidence and transmission probability point estimates are based on nonparametric bootstrapping with replacement over 1000 repetitions.

validated approach.[13] To identify individuals with late-stage disease, we linked the HIV data to information from a demographic surveillance. Individuals who died <15 months after the date of their HIV test were classified as late-stage HIV infection.

We estimated the expected transmission probability in a random sex act between a community member and a susceptible individual by weighting early-, latent- (i.e., neither early nor late), and late-stage HIV prevalence by stage-specific transmission probabilities, as estimated in a recent meta-analysis.[15] Per sex act, individuals in the early (late) disease stage are approximately nine (seven) times more likely to transmit HIV than individuals in the latent stage of HIV disease.[15] In the ranking of communities, tied ranks were assigned the average of the ranks that would have been assigned without ties.

In total, 11,786 individuals were included in the study, on average 589 per *Isigodi*. The overall HIV prevalence across all *Izigodi* was 21.4% [95% confidence interval (CI) 20.7–22.1%]; early-stage, latent-stage, and late-stage HIV prevalences were, respectively, 1.4% (95% CI 1.2–1.6%), 19.0% (95% CI 18.3–19.7%), and 1.0% (95% CI 0.9–1.2%). The three ranking schemes—by HIV prevalence, incidence, and transmission probability—led to significantly different community rank orders ($p = 0.0019$, using the Friedman test) (Graph 1). Table 1 shows the point and standard error estimates of prevalence, incidence, and expected transmission probability, as well as the associated rankings for each *Izigodi*. The standard errors for incidence and expected transmission probability were estimated using nonparametric bootstrapping with replacement over 1000 repetitions.

In comparison to prevalence-based ranking, only one of the 20 communities retained its position in each of the two alternative rankings, whereas in incidence-based (transmission probability-based) ranking 15 (12) communities moved three or more places, 10 (6) communities moved five or more places, and 6 communities (1 community) moved 10 or more places (Table 1). The three communities with HIV prevalence >25% did not move more than two places when comparing ranking based on prevalence to either incidence- or transmission probability-based ranking. Among the 17 communities with lower prevalence, substantially larger changes in rank order occurred, in particular when moving from prevalence- to incidence-based ranking (Table 1). Furthermore, the ratio of the highest to the lowest value among the 20 communities was larger in incidence comparison (11.0 per 100 person-years/0.4 per 100 person-years = 27.5) and transmission probability comparison (0.043/0.014 = 3.1) than in prevalence comparison (31.2%/14.1% = 2.2).

Our results demonstrate that resource allocation for HIV prevention based on ranking by HIV prevalence—e.g., giving most to the community with the highest and least to the community with the lowest prevalence—is unlikely to lead to the best possible use of prevention budgets (Fig. 1). For example, assume that policymakers had a budget to provide HIV acquisition prevention in half of the communities in our sample. If they choose to implement the prevention intervention in the 10 communities ranked highest according to prevalence instead of incidence, they would (wrongly) select communities E, F, G, I, and J instead of communities M, N, R, S, and T (see Table 1).

Although the rankings of point estimates by the three measures differ significantly from each other, due to sampling error, not all of the cross-community differences in the individual measures are statistically significant (Table 1). Nevertheless, our findings are relevant because policymakers are likely to focus on differences in ranking rather than the statistical significance of one-by-one comparisons of communities in ranking measures. Furthermore, in larger surveys covering wider geographic areas, such as national HIV surveys, the differences in ranking measures across subareas, such as provinces, are likely to be significant.

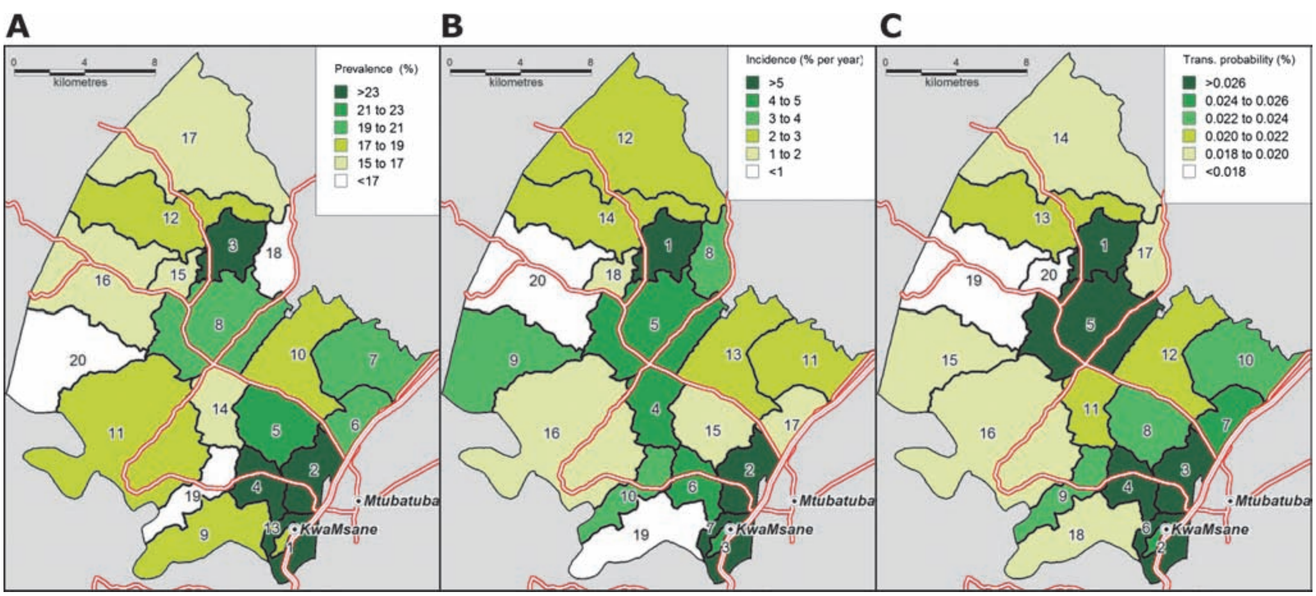

FIG. 1. Community ranking according to HIV prevalence, incidence, and transmission probability. Each homogeneously colored area is a traditional Zulu community, *Isigodi*. The numbers in the areas represent the community rank according to HIV prevalence (**A**), incidence (**B**), and transmission probabilities (**C**).

The addition of validated TRI to cross-sectional HIV surveys,[13] such as the DHS, would allow better prioritization for prevention of HIV acquisition than is currently possible. TRI are easy to apply. They involve additional laboratory testing of samples identified as HIV infected in standard HIV antibody tests but do not require repeat testing of HIV-uninfected individuals to detect early-stage infection. Thus, they are less complex and less expensive to implement than longitudinal HIV surveillances and yield incidence estimates without the delay of a second round of testing. In a systematic review,[16] we identified 39 published studies (up to March 2009) that estimated HIV incidence based on information obtained by applying the BED assay, the particular TRI used in the present study. Past applications of the BED assay included national and subnational HIV surveys of general populations in sub-Saharan Africa,[13,17,18] demonstrating that it is indeed feasible to add TRI to large-scale surveys in the region. Further studies are needed to estimate the cost-effectiveness of routinely adding TRI to HIV surveys in sub-Saharan Africa.

The further addition of information on the proportion of individuals with late-stage disease could improve prioritization for prevention of HIV transmission, or "positive prevention." In most settings in sub-Saharan Africa, data on HIV-specific mortality, which could be used to estimate the proportion of individuals with late-stage HIV disease, is unlikely to be available because the vital registration systems in most countries in the region record only small proportions of all deaths[19] and among the recorded deaths HIV is commonly underreported as a cause.[20] However, alternative approaches to measure cause-specific mortality in developing countries have recently been developed and validated in some settings. These approaches include verbal autopsy based on symptom pattern, which could be applied in household surveys, and estimation of cause-specific mortality statistics using deaths records routinely collected in health care facilities.[21–23] The use of cause-of-death data in prioritizing communities for HIV prevention adds another reason to the many existing ones as to why such data are of critical importance for health policy.

In sum, policymakers aiming to identify communities to target for HIV prevention should consider collecting information on disease stage in addition to HIV status, using locally validated methods.

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Address correspondence to:
Till Bärnighausen
Africa Centre for Health and Population Studies
University of KwaZulu-Natal
3935 Mtubatuba
KwaZulu-Natal, South Africa

E-mail: tbarnighausen@africacentre.ac.za