Title: Community-based conservation reduces risk of HIV infection and spread

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Community-based conservation programs, whereby local communities design and actively participate in biodiversity conservation, have received mixed reviews on their effectiveness (*1, 2*). However, quantitative evaluations of their impacts on other outcomes of interest are scarce, especially those using rigorous program evaluation methods (*3*). This is especially true of impacts on human health, an area of emerging concern for conservation and global public health policy (*4*). Here, we show that a national community-based conservation program in Namibia has had remarkable success in reducing the main behavioural determinant of HIV/AIDS infection in Africa.

Namibia's Community-Based Natural Resources Management (CBNRM) program has been in existence since the 1990s, with demonstrated positive effects in recovering wildlife populations and in increasing incomes to communal conservancies (*5, 6*). From 2003-2007, a community-based HIV/AIDS outreach and education program in 31 conservancies raised awareness of the disease through radio broadcasts, written material, and traditional song and dance; trained community "peer educators"; drafted HIV policies and plans; and disseminated condoms (*7*). We evaluated the impact of this program on men and women in conservancies relative to three separate comparison groups: all adults outside of conservancies, all adults in the nearest village outside of a conservancy, and adults from a quasi-experimental evaluation design that matched conservancy households with similar rural households outside of conservancies (see Supporting Online Material). We used georeferenced Demographic and Health Surveys (DHS) data from 2000 and 2006/2007 to assess whether changes in the trend of known HIV/AIDS risk factors (8) were related to whether men and women lived inside or outside of communal conservancies.

(see Methods section below)

From 2000 to 2006/2007 there was a dramatic (>60%) decline in the reported number of sexual partners over the last 12 months for men in conservancies. In contrast, the number of partners for men in comparison groups declined only slightly over the same time period (Fig. 1A, Table S1). Multiple concurrent sexual partners is the dominant driver of HIV/AIDS in sub-Saharan Africa [ref]; a program impact of 40-50 % relative to baseline behavioural levels is therefore important. In addition, the program resulted in a significant increase in the tendency for a man's last sexual partner to have been their wife (rather than a girlfriend, friend, or acquaintance), relative to non-conservancy comparison groups (Fig. 1B), and a maintenance, in the face of declines in comparison groups, of the duration that unmarried conservancy men had known their last sexual partner (Fig. 1C). These data suggest that the CBNRM HIV/AIDS program resulted in an increasing tendency towards monogamy on communal conservancies, an outcome corroborated by the strong decrease in condom use among conservancy men amid increasing usage in the comparison groups (Fig 1D). For the remaining men’s risk

factors, there was no statistical effect of communal conservancy residence on trend from 2000 to 2006/2007.

We did not observe the same positive impacts of the CBNRM program on women's risk factors. Only one variable, knowledge of where to get an AIDS test, significantly increased over time on conservancies relative to the matched sample. In contrast, three risk factors (condom use, AIDS testing, and age at first sex) actually showed a stronger improvement outside, rather than inside, conservancies. However, for all of these variables, there was a statistically significant positive main effect of conservancy residence, indicating that on average, women in conservancies were doing better than non-conservancy members across both years. The significant interaction therefore reflects a "catching up" of non-conservancy women relative to their conservancy counterparts (SOM, Table S1).

HIV/AIDS outreach programs and policies associated with Namibia's communal conservancy program have significantly reduced the primary behavioural determinant of the disease's spread in Africa. The increasing tendency towards monogamy on conservancies contradicts in-country conventional wisdom, based largely on anecdotal evidence, that the CBNRM program has had little effect on reducing risky sexual behaviour on communal conservancies (*7*). The CBNRM program made explicit the links among HIV prevention, sustenance of conservancy-based livelihoods, and individual and community survival, then engaged the entire conservancy community in behavior change communication and prevention activities. We believe the holistic and integrated approach taken by CBNRM created a foundation for programmatic success. Given the high prevalence of HIV in sub-Saharan Africa and the devastating effects that the disease has on the social and economic fabric of communities, especially with regard to natural resource management (9), lessons from Namibia's CBNRM program and the associated HIV/AIDS mainstreaming effort may help in slowing the disease in other communal areas of Africa.

References and Notes

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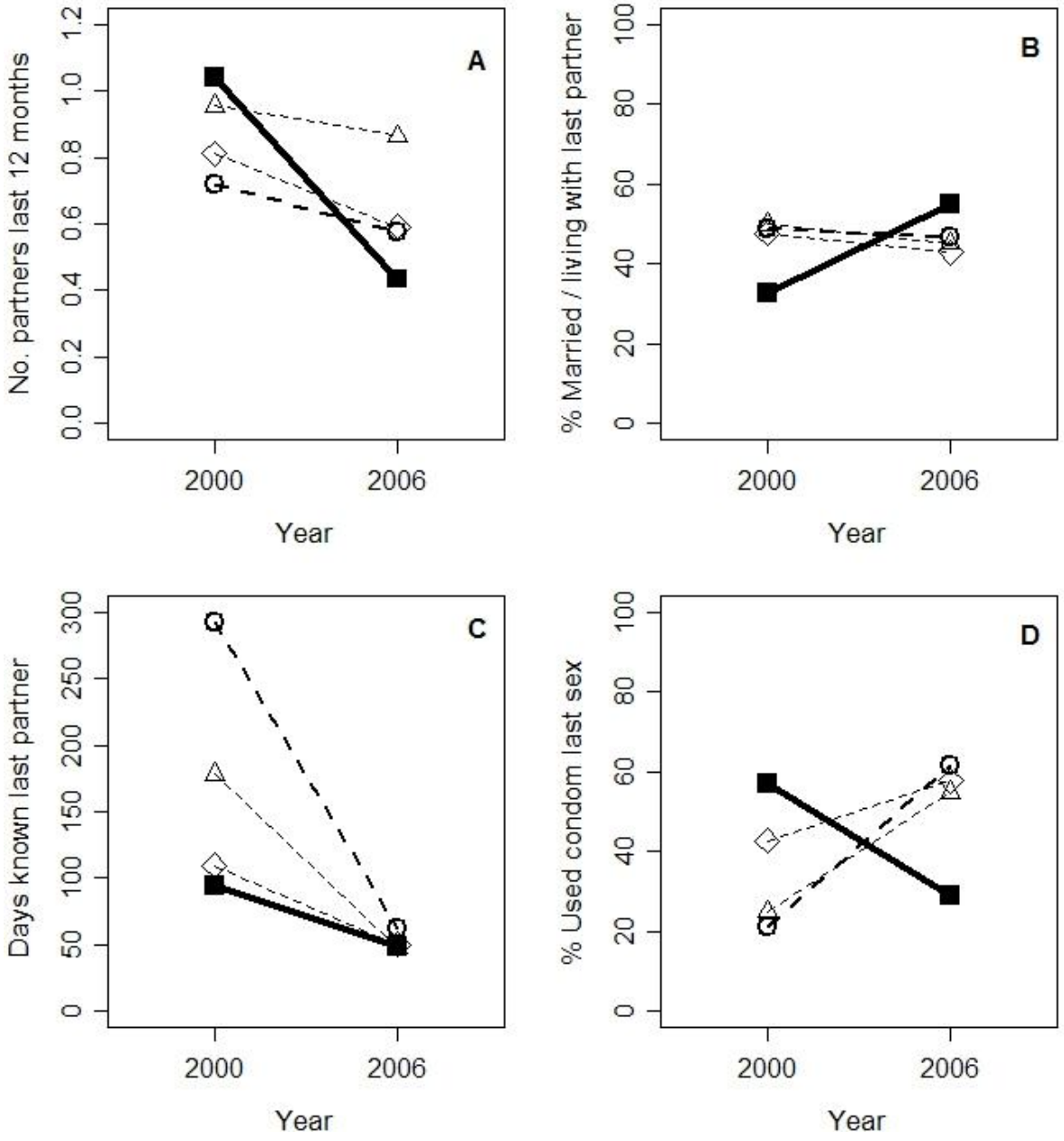
Figure Legend

Fig. 1. Changes from 2000 to 2006 for men inside conservancies (filled squares, solid line) versus matched comparison groups for **(A)** Number of sexual partners over the last 12 months; (**B**) Percentage of men married or living with their last sexual partner; (**C**) Length of time last sexual partner had been known; (**D**) Percentage of men who used a condom at last sexual encounter. Comparison groups are: all men outside of conservancies (dashed line, diamonds), all men in nearest sampling clusters (dashed line, triangles), and matched on socioeconomic and geographic variables (heavy dashed line, circles).



Methods

Data on HIV/AIDS risk factors in Namibia come from the nationally- and regionally-representative Demographic and Health Surveys (DHS): 204 households were surveyed in 8 conservancies in 2000, while 259 households in 10 conservancies were included in the 2006/07 survey. We used data on HIV-related knowledge, attitudes, and behaviors to construct outcome variables that reflect key risk factors for HIV/AIDS [5]. Questions were asked to women and men age 15-49.

We used three separate comparison groups of non-conservancy men and women against which to measure conservancy program impacts in trends of HIV/AIDS risk factors: (1) all men and women outside of conservancies; (2) all men and women in the nearest village (i.e., sampling "cluster") to each surveyed conservancy; and (3) a comparison group where statistical matching methods [6] were used to create a set of households that were similar to conservancy households in terms of characteristics that might confound conservancy impact on risk factors. Each comparison group was constructed for both 2000 and 2006/07.

For the matched comparison group, conservancy households were matched with households outside of conservancies by controlling for the following six geographic and socioeconomic variables:

(1) Urban / rural household
(2) Household size
(3) Distance to the nearest health clinic
(4) Wealth
(5) Precipitation
(6) Altitude

In addition, we restricted potential matches to those occurring in the same communal land region (of which there are 10 in Namibia) to control for variation in cultural norms, attitudes, and other geographical characteristics that may affect HIV/AIDS risk factors.

We used a Mahalanobis matching model (using the Matching library of the statistical software R [7]) with 1-to-1 nearest neighbour matching at the household level to create our comparison groups. Good post-matching balance was achieved for all of our covariates. Our final dataset for the matched comparison group included 117 men and 318 women in 2000 and 170 men and 357 women in 2006/07. Numbers were similar for the nearest village comparison group, while for comparison group (1) (all men and women outside of conservancies), the dataset included 2954 men and 6755 women in 2000 and 3915 men and 9804 women in 2006/07.

We evaluated the statistical significance of the main effects of year and conservancy residence, and a conservancy-year interaction term, using generalized linear models. Response family was either binomial, poisson, or negative binomial, depending on the nature of the response variable and whether count data were overdispersed. The key test of whether conservancies had an impact on temporal trends of HIV/AIDS risk

factors was whether the conservancy-year interaction coefficient was significantly different than zero (Table S1).

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