Temporal stability of HIV prevalence in high burden areas regardless of declines in national HIV prevalence in Malawi and Zimbabwe

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Word count: Text: 1248. Abstract: 100
Number of tables: 0
Number of figures: 1
Running head: Spatio-temporal dynamics of HIV

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Abstract

This study aims to assess the subnational temporal trends in HIV prevalence in Malawi and Zimbabwe. Using data from three Demographic and Health Surveys conducted in Malawi and Zimbabwe, we found that (i) national HIV prevalence in both countries substantially declined from 2004 to 2016, (ii) large declines occurred in areas where HIV prevalence was already low, and (iii) HIV prevalence in high burden areas remained stable over time. Well-designed HIV prevention programmes targeting hotspots are required for effective HIV control in countries with declining HIV prevalence.

Keywords: Spatial analysis, HIV hotspots, HIV prevalence declines, Resource allocation, Sub-Saharan Africa

Despite substantial reductions in the national HIV prevalence for several sub-Saharan Africa (SSA) countries, recent studies have identified important disparities in the decline of HIV prevalence at subnational levels [1-3]. Results from these studies suggest that the observed declines in HIV prevalence reflect aggregate measures at the national level, obscuring local variations in the spatio-temporal dynamics of the HIV epidemic. In a previous study, using data from multiple countries in SSA where at least two Demographic and Health Surveys (DHS) were conducted, we found that HIV prevalence sharply declined in areas where the prevalence was already low [3]. In contrast, HIV prevalence remained stable with no significant declines in the high HIV burden areas (areas with high HIV prevalence) within a country. In 2014 [3], Tanzania was the only country with three DHS surveys that included HIV serological biomarker data and the geographical coordinates of each surveyed location. The national HIV prevalence in Tanzania declined by 27% from 2003 to 2012. However, no declines were observed within the identified regions of high HIV prevalence, while low HIV prevalence regions experienced a 30% decline. These results suggest that subnational variation in the temporal dynamics of HIV prevalence could be sustained over large periods. However, the patterns of decline observed in Tanzania might be distinct. Generalizations about sustained subnational differences in the reduction of HIV prevalence require data from other countries.

Data from a third DHS survey, including HIV serological biomarker results and the geographical coordinates of each surveyed location, were recently released for Malawi and Zimbabwe, two countries where we previously found spatial disparities in HIV prevalence declines [3]. The additional data enables an exploration of the spatio-temporal dynamics of HIV prevalence over a large period (~10 years), thereby providing further insights into the current spatial variation in

declines of HIV prevalence in SSA. Therefore, this study aims to assess the subnational temporal trends in HIV prevalence in Malawi and Zimbabwe.

The main sources of data for our study were the DHS conducted in Malawi (2004, 2010, 2015-2016) [4] and Zimbabwe (2005–2006, 2010–2011, 2015) [5]. Regions with high HIV prevalence in these countries were identified in previous research [3]. The methods used to detect a geographical region with high HIV prevalence in Malawi and Zimbabwe as well as the epidemiological description of these regions are detailed elsewhere [3]. Briefly, spatial scan statistical analysis [6] was used to identify geographical regions with high numbers of HIV infections using data from the DHS conducted in Malawi in 2010 and in Zimbabwe in 2010-2011. In general, spatial scan statistics identify clusters with higher numbers of cases (e.g., HIV infections) than expected under a spatially random distribution of cases. Statistical significance is determined by gradually scanning the entire study area using circular windows with different radii. The areas of circular windows varied in size from zero to a maximum radius; the default scanning setting of a maximum spatial cluster size of 50% of the study population was used in the analysis. Using this methodology, an HIV infection cluster was detected in Malawi (located at the southern region of the country) and a cluster was detected in Zimbabwe (located at the southwestern part of the country between the provinces of Matabeleland North and South, and Midlands). Cluster size in Malawi was 162 km radius and included 38.6% of the total sampled population in 2015. Cluster size in Zimbabwe was 168 km radius and included 25.8% of the total sampled population in 2015 (Table S1). There were minor differences in the characteristics of the populations living within versus outside the clusters for both countries, with no identified associations of epidemiological significance [3] (Table S2 and S3).

Using data from the three rounds of the DHS in Malawi and Zimbabwe, temporal trends in HIV prevalence were assessed at the national level, and within the high HIV prevalence areas and outside these areas using the Cochran-Armitage Trend Test [7]. Our results indicate that the national HIV prevalence in Malawi declined by 26.7%, from 12% in 2004 to 8.8% in 2016 (P = 0.021; Figures 1A, B, C, G). However, no evidence of a statistically significant decline was observed within the region of high HIV prevalence, where a slight decline from 14.8% in 2004 to 13.7% in 2016 occurred (P = 0.8; Figure 1I). In contrast, the HIV prevalence in the region with low HIV prevalence declined by 39.1%, from 11% in 2004 to 6.7% in 2016 (P < 0.001; Figure 1H). Similar trends occurred in Zimbabwe. The national HIV prevalence in Zimbabwe declined by 22.2%, from 18% in 2005 to 14% in 2015 (P = 0.015; Figures 1D, E, F, G), but no statistical evidence of a decline was observed in the region of high HIV prevalence (P = 0.5; Figure 1I; prevalence of 18.9% in 2005 and 18.4% in 2015). The HIV prevalence in the region with low HIV prevalence declined by 21.1%, from 17.5% in 2005 to 13.8% in 2015 (P = 0.023; Figure 1H).

According to our results, the national HIV prevalence in both countries substantially declined, but subnational differences in the change of HIV prevalence persisted over a large time interval. HIV prevalence has remained stable in high prevalence areas (hotspots) over time with no observed significant declines. Most of the declines in HIV prevalence occurred in areas with low HIV prevalence. These patterns may be the result of several epidemiological synergies. Sustained high HIV prevalence in the hotspots could be the result, among other factors, of consistently high HIV transmission intensity occurring over time in the HIV hotspots, with a reduced transmission intensity occurring in regions outside of these high burden areas. Incidence rate estimations by province in Zimbabwe in 2013 indicate that the provinces with the highest

incidence rate were Bulawayo (2.5%) and Matabeleland South (1.4%) [8], which are provinces located within the hotspot identified here (Figure S1A). But other important factors might play a fundamental role in the HIV prevalence disparities observed here. Rapid declines in areas with low HIV prevalence could reflect HIV treatment and care disparities resulting in high HIV mortality due to lack of HIV treatment and care. However, although there are small geographical differences among ART coverage in Zimbabwe [9] and Malawi [10], provinces located in the high burden areas of Zimbabwe such as Matabeleand North and South have lower ART coverage compared with provinces located in areas with low HIV prevalence such as Mashonaland West, Central and Eastho, and Masvingo (Figure S1B), and there was not a distinct geographical pattern on the ART coverage in Malawi (Figure S2). Moreover, we observed no differences in the percentage of people tested for HIV within the hotspots and outside these areas in both countries (Table S2 and S3).

Spatial variations in the drivers of the HIV epidemic such as high HIV incidence, HIV treatment and care disparities, high risk sub-populations, and migration among other factors could be generating marked geographical differences in the temporal evolution of the epidemic within a country, and could be among the key drivers for the sustained high HIV prevalence in these areas that prevent significant reduction in HIV prevalence. Our findings suggest that HIV policies that fail to account for the spatio-temporal heterogeneity of the HIV epidemic are inherently biased and could substantially limit the overall effectiveness of the current repertoire of HIV prevention programmes [11, 12]. Therefore, programmes that target hotspots will more effectively control epidemics, compared to interventions deployed outside of the areas where HIV prevalence has been declining.

Acknowledgments

The authors are thankful for Measure Demographic and Health Surveys (Measure DHS) for putting these national surveys in the service of science, and for the United States Agency for International Development and other donors supporting these initiatives.

Authors and contributors

DFC conceived the study and its design, conducted most of the statistical analyses, and wrote the first draft of the paper. AJB contributed to study conception and design, conduct of the statistical analyses, interpretation of the results, and writing of the manuscript. ZM contributed to study conception and design, conduct of the statistical analyses, interpretation of the results, and writing of the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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Figures

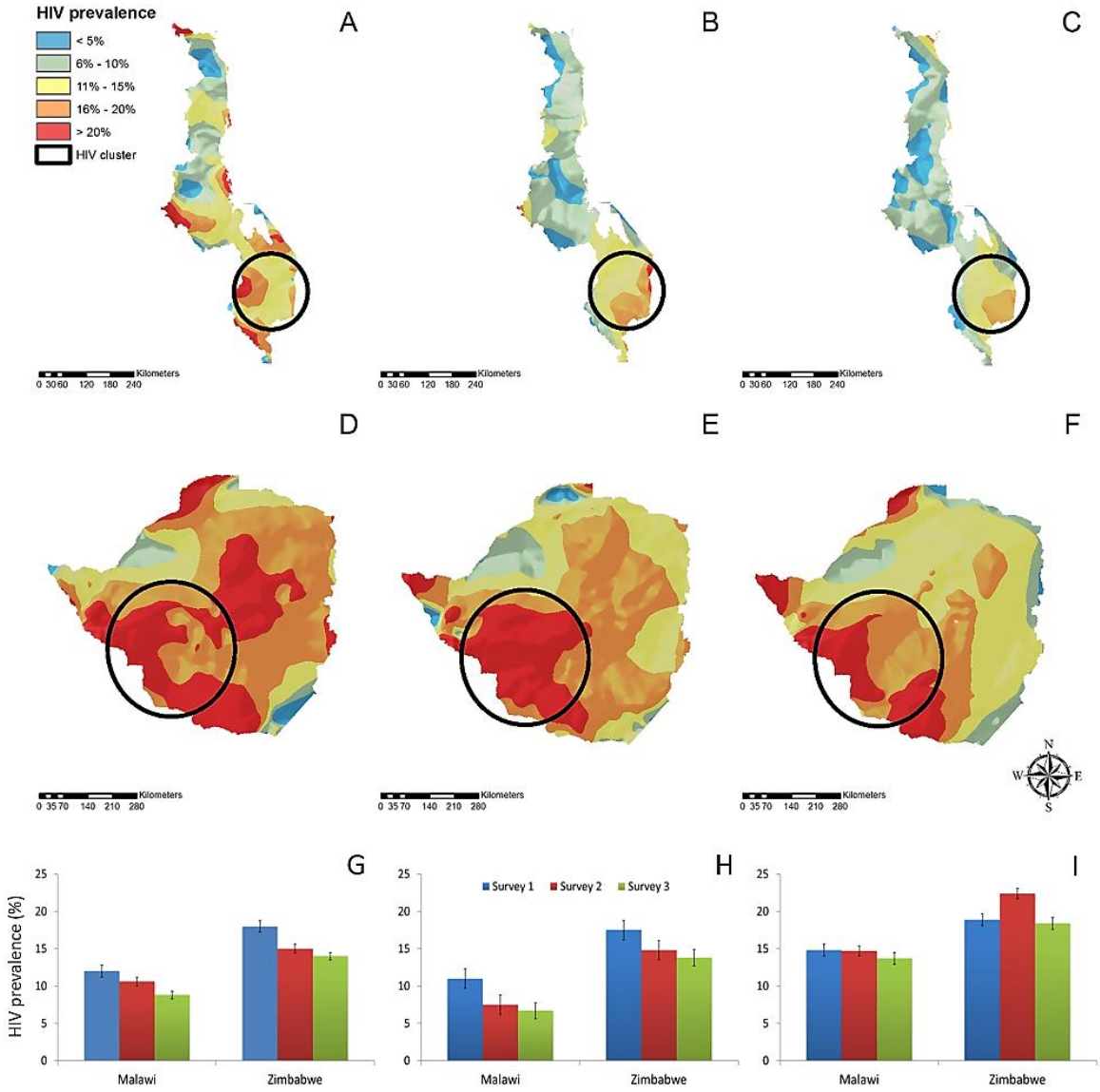

Figure 1 – Temporal trends in the clustering of HIV infection in Malawi and Zimbabwe. Spatial locations of the high HIV prevalence cluster in Malawi 2004 (A), 2010 (B), and 2015-16 (C). Spatial locations of the high HIV prevalence cluster in Zimbabwe 2005-06 (D), 2010-11 (E), and 2015 (F). Continuous surfaces of HIV prevalence within a country were generated using a kernel density mapping algorithm [13]. Bar charts illustrate the temporal trend in national HIV prevalence (G), HIV prevalence outside the high HIV prevalence clusters (H), and HIV prevalence within the high HIV prevalence clusters (I)