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DEVELOPING SUBNATIONAL ESTIMATES OF HIV PREVALENCE AND THE NUMBER OF PEOPLE LIVING WITH HIV

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METHODOLOGY NOTE

Developing subnational estimates of HIV prevalence and the number of people living with HIV from survey data

Introduction

Significant geographic variation in HIV incidence and prevalence, as well as programme implementation, has been observed between and within countries. Methods to generate subnational estimates of HIV prevalence and the number of people living with HIV are being explored in response to the urgent need for data at smaller administrative units, in order to inform programming that is aligned with local community needs.

This guidance note describes existing methods to generate subnational estimates of HIV prevalence and the number of people living with HIV from survey data, with a particular focus on the development of maps of estimates at second administrative level through the prevR model *(1)* as a data visualization resource. Although HIV estimates at the first administrative level can be generated through various methods and sources for countries with available data, HIV estimates at the second administrative level are not currently available. Estimates at the second administrative level generated through prevR must be interpreted with caution; however, they provide an indication of the status of the epidemic subnationally within a country. A more complex method for estimating HIV prevalence and other variables at the second administrative level is being further developed, which will be integrated with existing Joint United Nations Programme on HIV/AIDS (UNAIDS) estimation processes.

prevR

Applying the prevR method to generate maps of estimates of the number of people living with HIV (aged 15–49 and 15 and older) and of HIV prevalence (aged 15–49) at the second administrative level was recommended by participants at a technical consultation on methods for generating subnational estimates. This consultation, held in Nairobi, Kenya, 24–25 March 2014, was convened by the HIV Modelling Consortium, the UNAIDS Reference Group on Estimates, Modelling and Projections and the UNAIDS Task Force on Hotspots. It served as a follow-up to the July 2013 consultation on identifying populations at greatest risk of infection, which focused on geographic hotspots and key populations.

The countries to which this method was applied were selected based on the availability of data from Demographic and Health Surveys (DHS) or AIDS Indicator Surveys (AIS), which included georeferenced and HIV testing data gathered since 2009. Beginning in 2009, the displacement of DHS cluster data[1] was restricted to the second administrative level *(2)*.

1. In DHS surveys, clusters (groupings of households) are georeferenced, with a random displacement of latitude and longitude. Urban clusters are displaced by a maximum of 2 km and rural clusters by a maximum of 5 km, with 1% displaced 10km. Please see reference 2 for details. Displacement is restricted to within a country and to survey regions, and, since 2009, has also been restricted to the second administrative level, where possible.

Method

The survey data have been spatially distributed using a kernel density approach with adaptive bandwidths based on a minimum number of observations in order to generate estimates of HIV prevalence among people aged 15–49 years. This method was described in detail elsewhere *(1)* and was implemented in the prevR package (in R language).

The basic principle of the prevR method is to calculate an intensity surface of positive cases and an intensity surface of observations. The ratio of positive cases to observations results in the prevalence surface.

The intensity surface of observations is expressed as the number of observations per surface area (per square degree or per square km, depending on the coordinate system). The volume below this surface is equal to the total number of observations in the dataset. This surface indicates how observations are distributed from a scatterplot on a continuous surface.

For each administrative unit, the integral of the intensity surface is calculated (i.e. the corresponding volume below this surface) to obtain the number of distributed observations in that administrative unit.

Results are merged per administrative unit and uncertainty bounds are calculated as 95% confidence intervals based on the distributed number of observations (through kernel density estimations) per unit. This confidence interval is wider in less-surveyed areas and narrower in areas with several survey clusters.

The spatial distribution of the population is based on LandScan, which is used to generate the spatial distribution of the population aged 15 to 49 and the population aged 50 and over, adjusted to estimates of the total population aged 15 to 49 and 15 and older from Spectrum.[2]

The spatial distribution of HIV prevalence and people living with HIV was estimated using prevR and DHS data. Prevalence among the population 50 years and older was computed using a prevalence ratio derived from UNAIDS estimates produced using Spectrum software *(3)*.

Finally, estimates were adjusted to UNAIDS estimates of the number of people living with HIV aged 15–49 and 15 and older *(3)*. National estimates obtained by aggregating subnational estimates of the number of people living with HIV and HIV prevalence generated using this method will, therefore, match UNAIDS estimates.

UNAIDS estimates are midyear estimates. For countries with a DHS conducted during a single year, the estimates are adjusted to the same year. For countries with DHS conducted over two years, estimates are adjusted to UNAIDS estimates for the second year of the survey.

2. Population estimates were obtained through the Spectrum module DemProj. These estimates are based on the United Nations Population Division's World Population Prospects 2012. Some differences may exist between the United Nations Population Division estimates and those obtained through Spectrum. United Nations Population Division estimates are input into Spectrum, and are then adjusted within Spectrum by removing the estimated population of people living with HIV, which is then added back through the estimation process. This process is limited to the 39 high-burden countries.

The main hypotheses of this method are as follows:

- The age structure are uniform across the country.
- Population-based survey data is used only to define the shape of the prevalence surface, while the level of prevalence is defined by UNAIDS estimates.
- The spatial distribution of HIV among people aged 50 and over is equal to the spatial distribution of HIV among people aged 15 to 49.

Quality of the subnational estimates of HIV prevalence and number of people living with HIV generated through prevR

Subnational estimates are accompanied by a quality of estimates indicator and 95% confidence intervals. The estimate quality is categorized based on the following scale:

- Good: estimates are based on observations from the same subnational area.
- Moderately good: estimates are primarily based on observations from the same subnational area.
- Uncertain: estimates are primarily based on observations from a neighbouring subnational area.
- Very uncertain: estimates are based only on observations from a neighbouring subnational area.

The quality of HIV estimates at the subnational level depends on the survey sample size. DHS was designed to be representative at the national and first administrative levels, but, in most countries, not at the second administrative level beyond the DHS regions. The number of observations per subnational area varies significantly. If some subnational areas have been sufficiently surveyed, others may be underrepresented. In that case, HIV prevalence has been estimated using observations from neighbouring areas and is categorized as uncertain or very uncertain. Uncertainty estimates correspond to variations between first administrative level areas and may be inaccurate when local variations are not captured by the survey. Sources of administrative area boundaries used to determine if an observation crossed over a second-level administrative border may have errors, therefore observations near border areas need to be considered as uncertain as to their location.

Areas with a higher relative HIV prevalence (expressed as a percentage) are not necessarily those with a higher absolute number of people living with HIV (represented on the people living with HIV density map) since the spatial distribution of the population is highly irregular.

Confidence intervals complement the quality of estimates indicator. Confidence intervals only take into account that estimates of the prevalence and the number of people living with HIV aged 15–49 are based on a limited number of observations. They do not consider the spatial dimension of the estimates.

How are subnational estimates of HIV prevalence and number of people living with HIV produced using prevR related to the UNAIDS estimation process using Spectrum?

UNAIDS estimates trends of HIV prevalence over time at the national level using multiple data sources including population-based surveys. This report estimates spatial subnational variations of HIV prevalence and the number of people living with HIV for a given year based on a unique population-based survey. Furthermore, the spatial distribution of observations is taken into account here. These two approaches should be considered complementary.

Data sources

The following data were used:

- DHS/AIS (http://www.dhsprogram.com/):
  - Burkina Faso, DHS, 2010,
  - Burundi, DHS, 2010,
  - Cameroon, DHS, 2011,
  - Côte d'Ivoire, DHS, 2011–2012,
  - Ethiopia, DHS, 2011,
  - Gabon, DHS, 2012,
  - Guinea, DHS-Multiple Indicator Cluster Survey (MICS), 2012,
  - Haiti, DHS, 2012,
  - Lesotho, DHS, 2009,
  - Malawi, DHS, 2010,
  - Mozambique, DHS, 2009,
  - Rwanda, DHS, 2010–2011,
  - Senegal, DHS-MICS, 2010–2011,
  - Sierra Leone, DHS, 2008,
  - United Republic of Tanzania, Tanzania HIV/AIDS and Malaria Indicator Survey (THMIS), 2011–2012,
  - Uganda, AIS, 2011 and
  - Zimbabwe, DHS, 2010–2011;

- LandScan for the global population distribution (http://web.ornl.gov/sci/landscan/);

- Administrative boundaries:
  - Global Administration Areas (GADM) (http://www.gadm.org/)
  - Rwanda, the National Statistics Institute of Rwanda (http://statistics.gov.rw/geodata);
  - Gabon and Uganda, Global Administrative Unit Layers (GAUL) (http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691)

- Background layers:
  - Google Maps API (https://www.google.com/maps)
  - OpenStreetMap (http://www.openstreetmap.org/); and

- UNAIDS 2013 HIV estimates.

Other methods for generating subnational HIV estimates

From DHS

HIV testing has been conducted by DHS since 2001, on the basis of which nationally representative estimates of HIV prevalence are produced. Estimates of HIV prevalence at the first administrative level are also produced. DHS is typically designed to be representative at the national and first administrative levels, but not at the subnational level more specific than the first administrative level. Prevalence estimates from DHS for countries that have included HIV testing in their surveys are available from the DHS website (https://dhsprogram.com/) through StatCompiler or through country reports or datasets.

Spectrum/Estimation and Projection Package (EPP)

Estimates for countries and first administrative level are generated using Spectrum/Estimation and Projection Package (EPP) based on the data available. Data sources include surveys of pregnant women attending antenatal clinics, population-based surveys, sentinel surveillance among key populations at higher risk, case reporting, programme data on antiretroviral therapy and prevention of mother-to-child transmission programmes and demographic data. The results from these models include a wide array of variables related to HIV including HIV prevalence and number of people living with HIV.

Annually, UNAIDS and its partners support country-level teams in producing national estimates using Spectrum. Every two years, UNAIDS and its partners conduct regional workshops to train national personnel on the tools and methodologies used to produce national estimates. Country-level teams are then responsible for calculating HIV estimates and projections. Regional estimates are produced separately for each region based on data only from that province *(4)*.
In several countries where data are available, including India, South Africa, Nigeria, Mozambique and Kenya, estimates have been produced at the regional level using Spectrum.

In Kenya for example, estimates were first produced at the provincial level[3] applying Spectrum/EPP by including province-level inputs. In the next step, the provincial-level estimates were disaggregated to the county level. Population projections for each province were based on the total fertility rates and mortality indicators from the Kenya DHS and adjusted to match the estimates from the national census. Population estimates for counties were taken from the National Bureau of Statistics. For each county, the prevalence was determined by examining surveillance and survey cluster data from 2003 to 2012. As stated in the report:

The prevalence estimate for 2013 for each county was multiplied by the population aged 15–49 in the county to estimate the number of [HIV-positive] adults. The number of [HIV-positive] adults in each county was adjusted so that the total across all counties in a province would equal the provincial total. Values for other indicators were first distributed by county according to the number of [HIV-positive] adults and then adjusted to match the provincial totals *(5)*.

3. Note that while the DHS/AIS were designed to inform at the level of the province, the provincial administrative level is no longer in existence in Kenya.

Disclaimer

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References:

1. Larmarange J, Vallo R, Yaro S, Msellati P, Méda N. Methods for mapping regional trends of HIV prevalence from Demographic and Health Surveys (DHS). CyberGeo: European Journal of Geography. 2011;558. doi:10.4000/cybergeo.24606.

2. Burgert, Clara R., Josh Colston, Thea Roy, and Blake Zachary. 2013. Geographic displacement procedure and georeferenced data release policy for the Demographic and Health Surveys. DHS Spatial Analysis Reports No. 7. Calverton, Maryland, USA: ICF International.

3. Methodology – understanding the HIV estimates. Geneva: Joint United Nations Programme on HIV/AIDS; 2013 (http://www.unaids.org/en/media/unaids/contentassets/documents/epidemiology/2013/gr2013/20131118_Methodology.pdf, accessed 7 July 2014).

4. Stover J, Brown T, Marston M. Updates to the Spectrum/Estimation and Projection Package (EPP) model to estimate HIV trends for adults and children. Sexually Transmitted Infections. 2012;88(Suppl 2):i11–.i16. doi:10.1136/sextrans-2012-050640.

5. National HIV indicators for Kenya: 2013. National AIDS and STI Control Programme; 2013.

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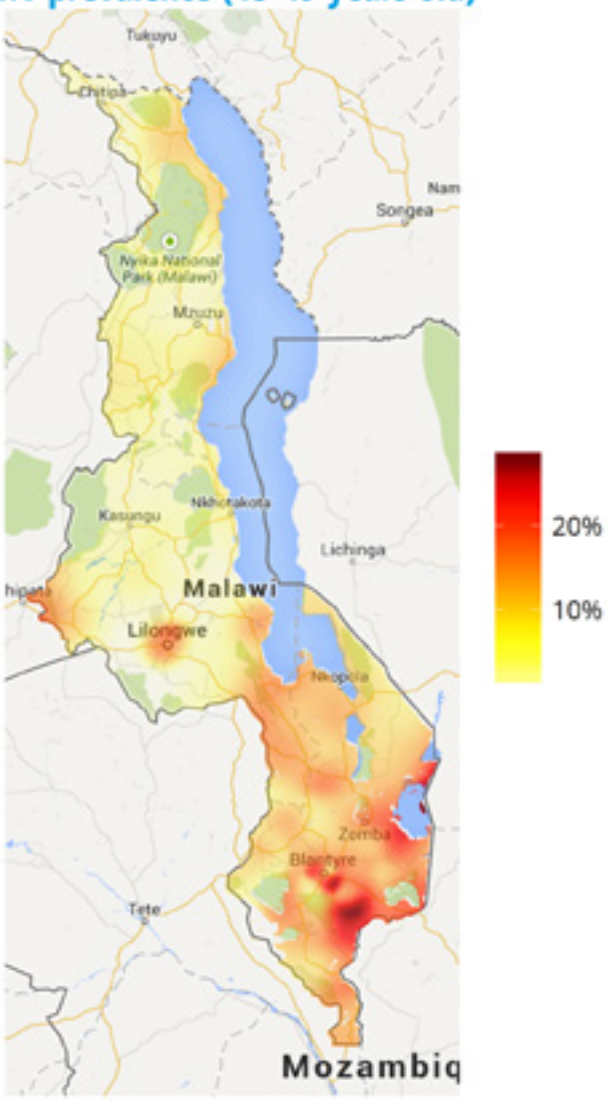
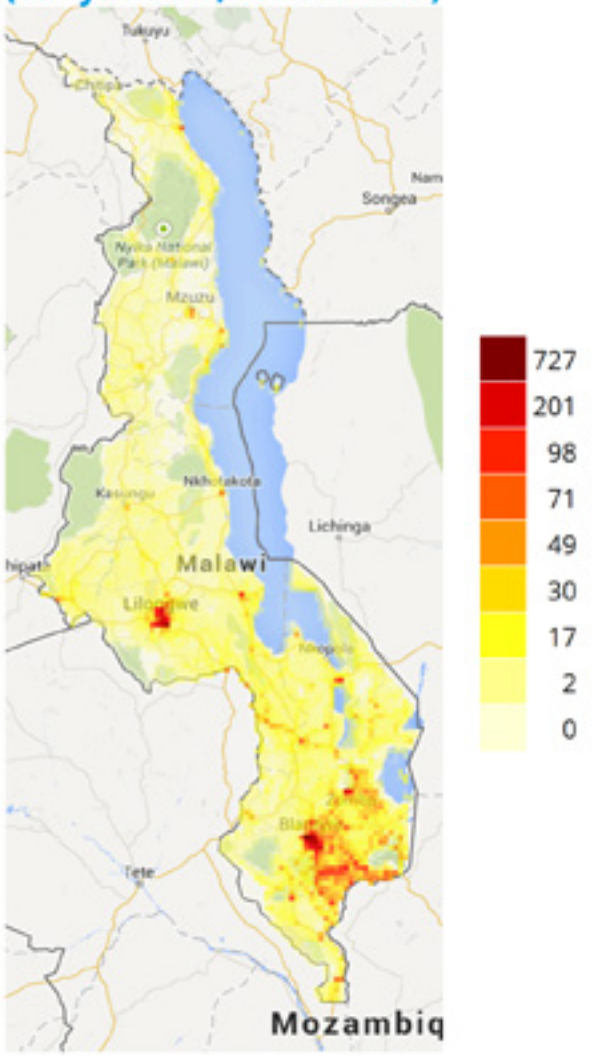
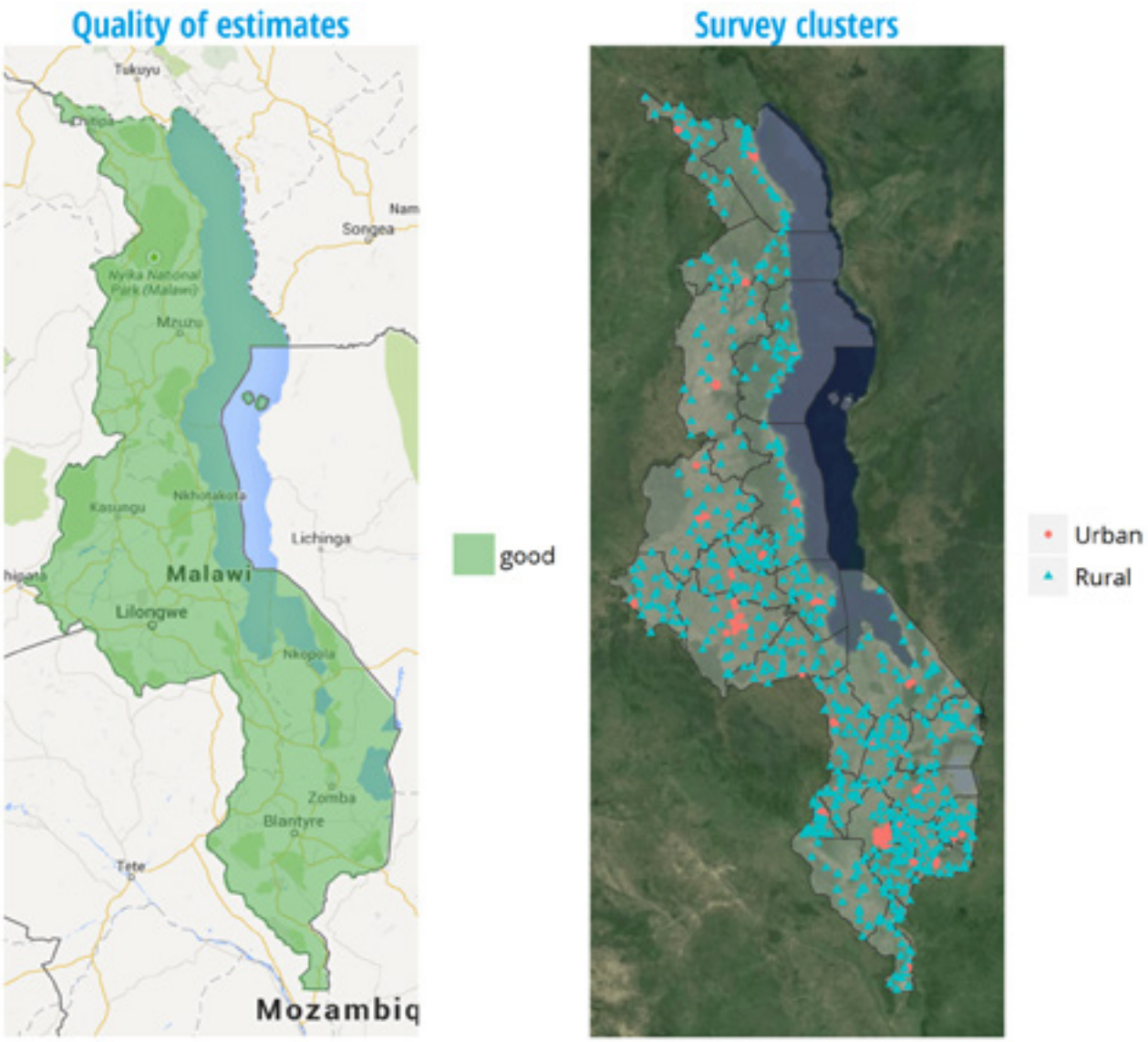
HIV estimates at district level

HIV prevalence (15-49 years old)



People living with HIV density (15+ years old, PLWHIV/km²)





Quality of estimates

- *Good:* estimates are based on observations from the same district.
- *Moderately good:* estimates are mainly based on observations from the same district.
- *Uncertain:* estimates are mainly based on observations from neighboring districts.
- *Very uncertain:* estimates are based only on observations from neighboring districts.

Quality of HIV estimates at district level depends on the sampling size of the 2010 Malawi DHS survey, where a total of 13 738 individuals (15-49 years old) were tested successfully for HIV in 825 survey clusters with geolocation.

Estimates per district

Region / District	HIV prevalence (15-49 years old)	People living with HIV (15-49 years old)	People living with HIV (15+ years old)	Quality of estimates
Central				
Dedza	8,20%	26 000	29 000	good
Dowa	5,20%	15 000	16 000	good
Kasungu	5,30%	17 000	19 000	good
Lilongwe	9,20%	80 000	89 000	good
Mchinji	10,30%	22 000	24 000	good
Nkhota Kota	5,90%	8 900	9 900	good
Ntcheu	14,80%	36 000	40 000	good
Ntchisi	4,50%	5 000	5 600	good
Salima	10,70%	18 000	20 000	good
Northern				
Chitipa	4,40%	3 600	4 100	good
Karonga	10,70%	14 000	15 000	good
Mzimba	6,30%	25 000	28 000	good
Nkhatabay	9,60%	11 000	13 000	good
Rumphi	6,70%	5 600	6 200	good
Southern				
Balaka	13,80%	23 000	26 000	good
Blantyre	17,80%	94 000	110 000	good
Chikwawa	13,40%	31 000	35 000	good
Chiradzulu	18,00%	28 000	31 000	good
Machinga	13,30%	32 000	36 000	good
Mangochi	11,80%	47 000	53 000	good
Mulanje	19,90%	56 000	63 000	good
Mwanza	11,60%	4 700	5 200	good
Neno	11,80%	5 800	6 500	good
Nsanje	15,50%	20 000	23 000	good
Phalombe	17,50%	27 000	30 000	good
Thyolo	21,60%	64 000	72 000	good
Zomba	16,30%	58 000	65 000	good
ALL	**12,00%**	**780 000**	**870 000**	

Uncertainty bounds

Region / District	HIV prevalence (15-49 years old)		People living with HIV (15-49 years old)		Quality of estimates
	Low	High	Low	High	
Central					
Dedza	5,70%	11,60%	18 000	37 000	good
Dowa	3,60%	7,50%	10 000	21 000	good
Kasungu	3,70%	7,60%	12 000	24 000	good
Lilongwe	7,30%	11,50%	64 000	100 000	good
Mchinji	7,60%	13,90%	16 000	29 000	good
Nkhota Kota	4,00%	8,40%	6 100	13 000	good
Ntcheu	11,80%	18,40%	29 000	45 000	good
Ntchisi	2,90%	6,90%	3 200	7 600	good
Salima	8,00%	14,10%	13 000	23 000	good
Northern					
Chitipa	2,30%	8,00%	1 900	6 600	good
Karonga	8,00%	14,20%	10 000	18 000	good
Mzimba	4,40%	8,80%	18 000	35 000	good
Nkhatabay	7,30%	12,40%	8 600	15 000	good
Rumphi	4,50%	9,90%	3 700	8 100	good
Southern					
Balaka	10,70%	17,50%	18 000	29 000	good
Blantyre	15,20%	20,80%	80 000	110 000	good
Chikwawa	10,40%	17,10%	24 000	40 000	good
Chiradzulu	14,50%	22,00%	23 000	35 000	good
Machinga	10,00%	17,40%	24 000	42 000	good
Mangochi	9,10%	15,20%	36 000	61 000	good
Mulanje	16,70%	23,50%	47 000	67 000	good
Mwanza	8,10%	16,10%	3 300	6 500	good
Neno	8,70%	15,70%	4 300	7 700	good
Nsanje	11,10%	21,10%	15 000	28 000	good
Phalombe	13,80%	21,80%	21 000	34 000	good
Thyolo	18,00%	25,70%	54 000	77 000	good
Zomba	13,30%	19,80%	48 000	71 000	good
ALL	**11,40%**	**12,50%**	**740 000**	**820 000**	

Guidance

Please refer to the methodology note on Developing subnational estimates of HIV prevalence and the number of people living with HIV available on http://www.unaids.org.

Data sources

- DHS Malawi 2010 (http://www.dhsprogram.com/)
- 2013 UNAIDS estimates computed with Spectrum/EPP (http://www.unaids.org/en/dataanalysis/datatools/spectrumepp2013/)
- LandScan 2012 for global population distribution (http://web.ornl.gov/sci/landscan/)
- GADM for administrative boundaries (http://www.gadm.org/)
- Google Maps API for background layers (https://www.google.com/maps)

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This report has been written for UNAIDS by Joseph Larmarange (IRD / Ceped) in July 2014.

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