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

UNAIDS / JC2665E (English original, September 2014)

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

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.

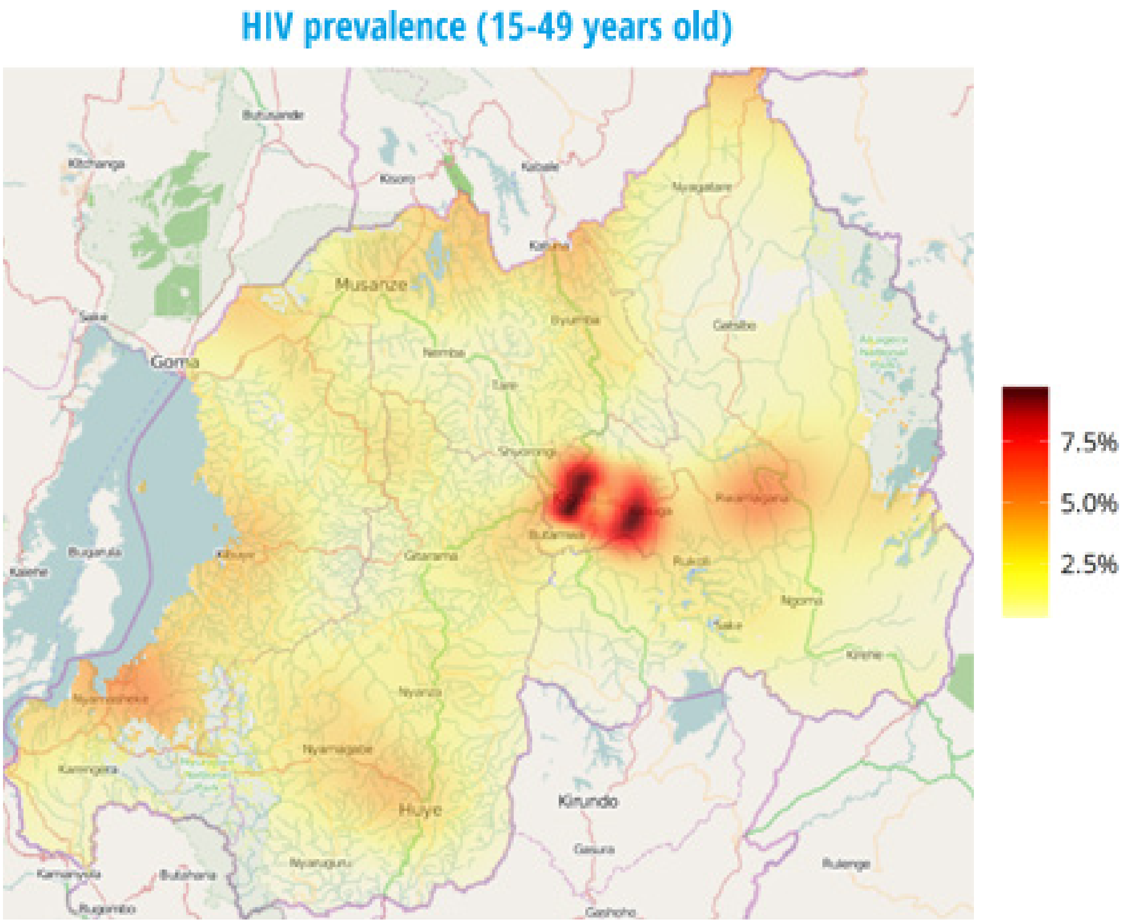
3. Methodology – understanding the HIV estimates. Geneva: Joint United Nations Programme on HIV/AIDS; 2013 (http://www.unaids.org/en/media/unaids/contentassets/documents/epidemiology/2013/gr2013/20131118_Methodology.pdf, accessed 7 July 2014).

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.

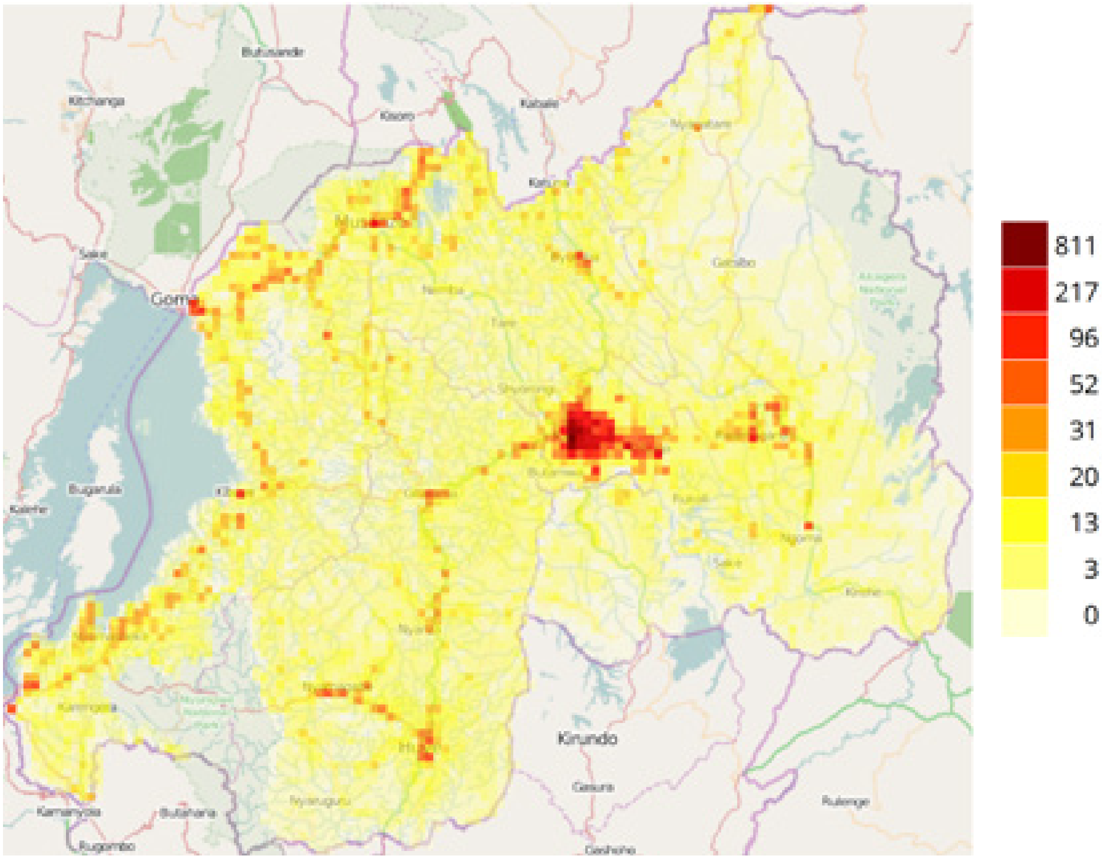
5. National HIV indicators for Kenya: 2013. National AIDS and STI Control Programme; 2013.

RWANDA

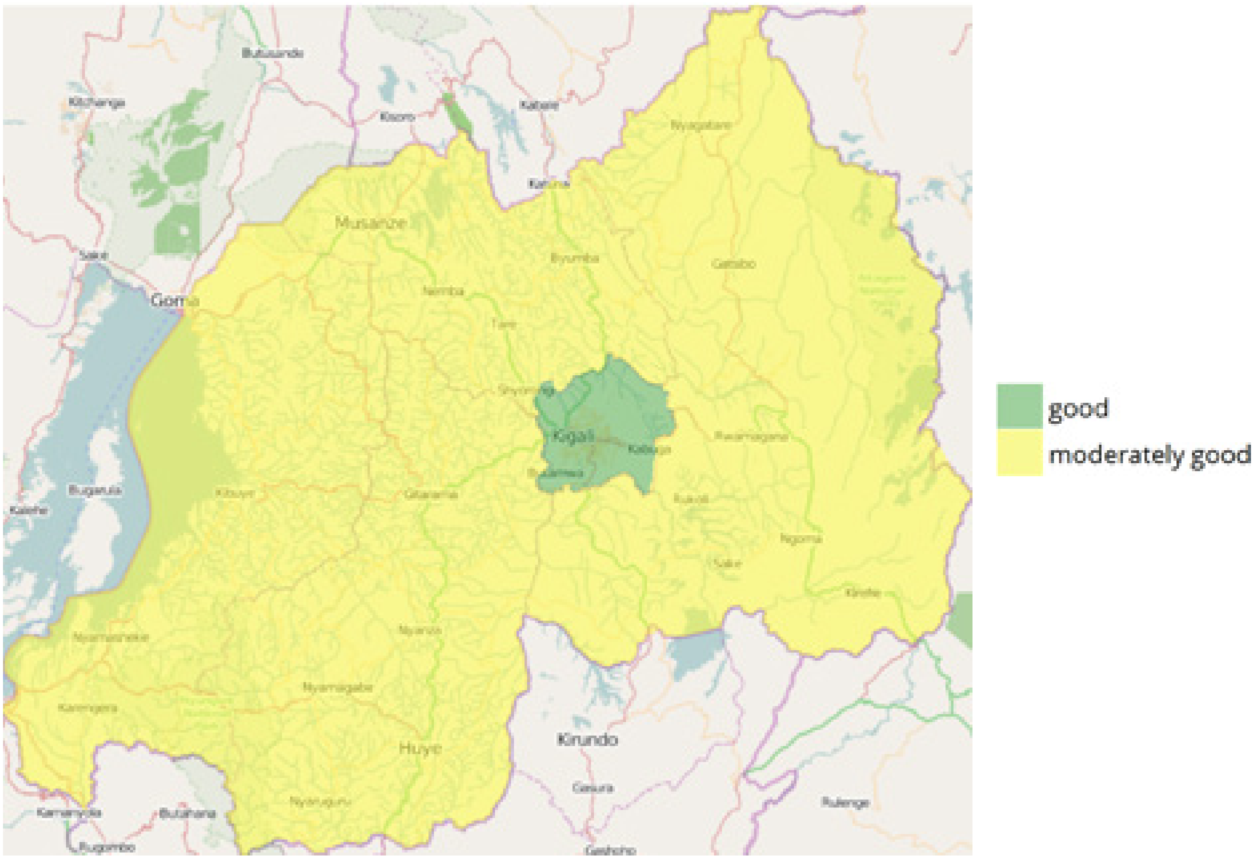
HIV estimates at district level



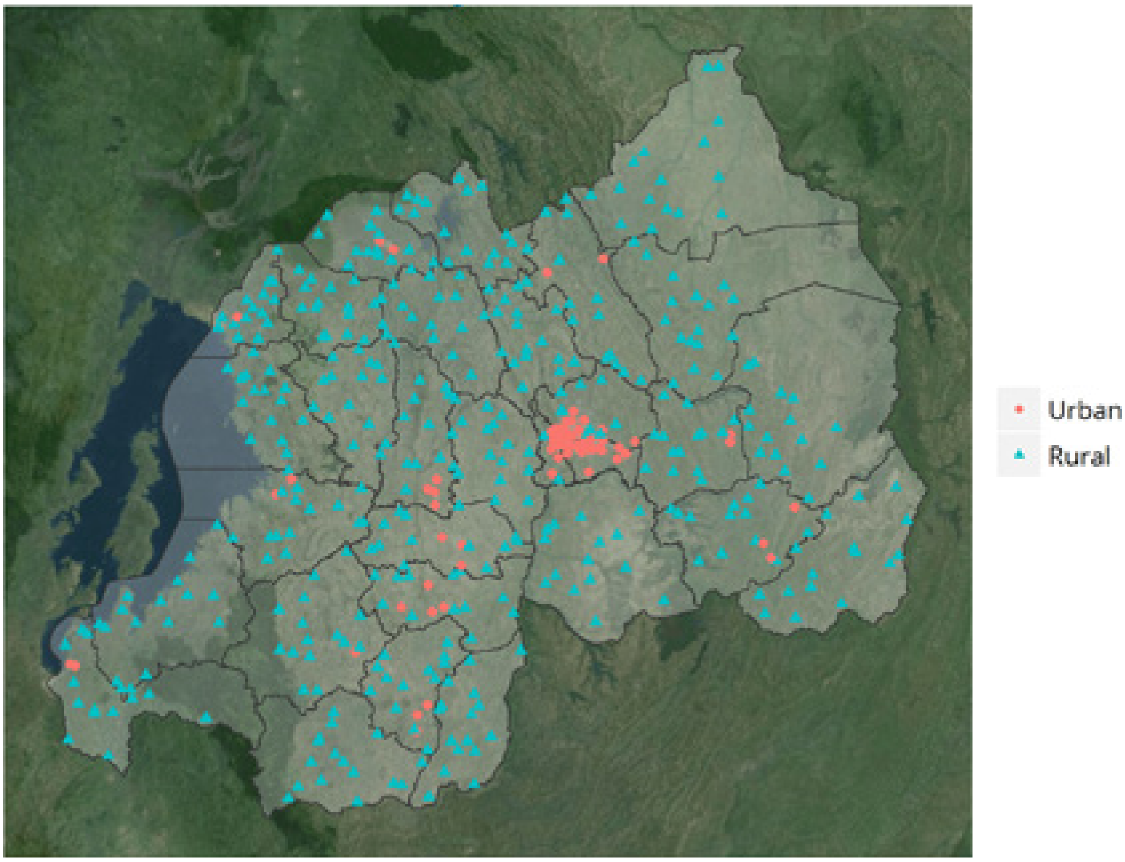
People living with HIV density
(15+ years old, PLWHIV/km²)



Quality of estimates



Survey clusters



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 2010/11 Rwanda DHS survey, where a total of 12 877 individuals (15-49 years old) were tested successfully for HIV in 492 survey clusters with geolocation.

Estimates per district

Province / 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
Eastern Province				
Bugesera	1,70%	2 800	3 300	moderately good
Gatsibo	1,40%	2 800	3 300	moderately good
Kayonza	3,40%	5 500	6 400	moderately good
Kirehe	1,30%	2 100	2 500	moderately good
Ngoma	2,40%	3 800	4 500	moderately good
Nyagatare	2,00%	4 200	4 900	moderately good
Rwamagana	4,20%	6 000	7 100	moderately good
Kigali City				
Gasabo	6,50%	17 000	19 000	good
Kicukiro	6,90%	9 000	11 000	good
Nyarugenge	8,20%	11 000	13 000	good
Northern Province				
Burera	3,30%	5 300	6 200	moderately good
Gakenke	1,70%	2 700	3 100	moderately good
Gicumbi	2,70%	5 000	5 900	moderately good
Musanze	2,90%	5 100	5 900	moderately good
Rulindo	2,00%	2 700	3 100	moderately good
Southern Province				
Gisagara	1,80%	2 600	3 000	moderately good
Huye	3,40%	5 200	6 100	moderately good
Kamonyi	2,90%	4 600	5 300	moderately good
Muhanga	2,30%	3 400	4 000	moderately good
Nyamagabe	3,00%	4 800	5 600	moderately good
Nyanza	2,40%	3 600	4 200	moderately good
Nyaruguru	1,50%	2 000	2 300	moderately good
Ruhango	2,20%	3 200	3 800	moderately good
Western Province				
Karongi	2,90%	4 400	5 200	moderately good
Ngororero	2,40%	3 700	4 300	moderately good
Nyabihu	2,80%	4 000	4 600	moderately good
Nyamasheke	4,00%	7 100	8 300	moderately good
Rubavu	2,50%	4 600	5 400	moderately good
Rusizi	2,10%	3 800	4 400	moderately good
Rutsiro	2,80%	4 200	4 900	moderately good
ALL	**3,00%**	**150 000**	**170 000**	

Uncertainty bounds

Province / District	HIV prevalence (15-49 years old)		People living with HIV (15-49 years old)		Quality of estimates
	Low	High	Low	High	
Eastern Province					
Bugesera	0,70%	3,70%	1 200	6 300	moderately good
Gatsibo	0,60%	3,20%	1 100	6 400	moderately good
Kayonza	2,00%	5,70%	3 300	9 100	moderately good
Kirehe	0,40%	3,90%	620	6 100	moderately good
Ngoma	1,20%	4,80%	1 900	7 500	moderately good
Nyagatare	0,80%	4,60%	1 700	9 600	moderately good
Rwamagana	2,60%	6,60%	3 700	9 600	moderately good
Kigali City					
Gasabo	4,90%	8,60%	12 000	22 000	good
Kicukiro	5,00%	9,30%	6 600	12 000	good
Nyarugenge	6,10%	10,70%	8 600	15 000	good
Northern Province					
Burera	1,70%	6,30%	2 700	10 000	moderately good
Gakenke	0,80%	3,60%	1 200	5 600	moderately good
Gicumbi	1,40%	5,10%	2 600	9 400	moderately good
Musanze	1,50%	5,30%	2 700	9 200	moderately good
Rulindo	0,90%	4,10%	1 200	5 500	moderately good
Southern Province					
Gisagara	0,70%	4,10%	990	6 000	moderately good
Huye	1,90%	5,80%	2 900	8 900	moderately good
Kamonyi	1,50%	5,20%	2 400	8 300	moderately good
Muhanga	1,10%	4,50%	1 600	6 800	moderately good
Nyamagabe	1,70%	5,30%	2 600	8 400	moderately good
Nyanza	1,20%	4,80%	1 700	7 100	moderately good
Nyaruguru	0,50%	3,70%	690	5 100	moderately good
Ruhango	1,00%	4,40%	1 500	6 400	moderately good
Western Province					
Karongi	1,50%	5,50%	2 300	8 300	moderately good
Ngororero	1,20%	4,60%	1 800	7 100	moderately good
Nyabihu	1,60%	5,00%	2 200	7 000	moderately good
Nyamasheke	2,20%	6,80%	4 000	12 000	moderately good
Rubavu	1,10%	5,30%	2 100	9 700	moderately good
Rusizi	0,90%	4,70%	1 500	8 500	moderately good
Rutsiro	1,50%	4,90%	2 300	7 400	moderately good
ALL	**2,70%**	**3,30%**	**130 000**	**160 000**	

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 Rwanda 2010/11 (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/)
- National Statistics Institute of Rwanda for administrative boundaries (http://www.statistics.gov.rw/geodata)
- OpenStreetMap for background layers (http://www.openstreetmap.org/)

Disclaimer

The designation employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of UNAIDS concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. UNAIDS does not warrant that the information published in this publication is complete and correct and shall not be liable for any damages incurred as a result of its use.

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

Printed on FSC-certified paper

UNAIDS
Joint United Nations
Programme on HIV/AIDS

UNHCR
UNICEF
WFP
UNDP
UNFPA
UNODC
UN WOMEN
ILO
UNESCO
WHO
WORLD BANK

20 Avenue Appia
1211 Geneva 27
Switzerland

+41 22 791 3666
distribution@unaids.org

unaids.org