Projection of HIV Incidence Trends in Zimbabwe Using Incremental Mixture Importance Sampling

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***Abstract*—HIV prevalence has remained high in Zimbabwe due to continued use of Antiretroviral therapy (ART). Incidence is now a better measure of the programmatic efforts in response to the epidemic. Mathematical modeling remains the main tool for assessing incidence trends. Secondary data transmembrane (TM) one, that is [TM1] analysis, was conducted using incremental mixture sampling (IMIS). Absolute neutrophil count (ANC) [TM2] prevalence data were used for modeling incidence in the general population. The force of infection in 6 of the 10 provinces in Zimbabwe is projected to fall below 1%. ART has significantly helped in reducing the force of infection in the country. With continued use of ART coupled with other programmatic interventions, HIV incidence can be reduced to very low levels in many parts of the country. HIV incidence in Zimbabwe varies by geographical location. Matabeleland South province has the highest cumulative incidence in the country, while Harare province has the lowest. There is a difference in the force of infection between rural and urban areas. The force of infection remains high in the Matabeleland South, Midlands, Bulawayo, and Mashonaland East provinces. An increase in the use of ART reduces HIV incidence. Scaling up HIV counselling and testing activities in provinces or districts with high force of infection will help reduce the force of infection in these areas as the number of people on ART will increase, consequently reducing the infectiousness of infected people. Intervention programmes should address cultural differences.**

Keywords: Incidence, Force of infection, Geographical location, Anti-retroviral treatment, Incremental mixture sampling

I. Introduction

Human Immunodeficiency Virus (HIV) is a retrovirus that causes a chronic infection, which leads to acquired immunodeficiency syndrome (AIDS) in human beings. [1] The virus progressively depletes CD4 T lymphocytes, which are important in coordinating immune responses to pathogen attacks, thereby weakening the body's ability to fight infections. Pathogenic organisms and commensals then exploit the weakened immune system to invade the body and cause opportunistic infections (OIs). These OIs, when occurring in the context of a profoundly suppressed immune system, characterize the acquired immunodeficiency syndrome (AIDS), which, in untreated subjects, leads to death within two years on average.

In Sub-Saharan Africa, where HIV is most prevalent, HIV infection is mainly through unprotected heterosexual intercourse and vertically from a mother to her child during pregnancy, delivery, birth, and breastfeeding, through mother-to-child transmission (MTCT).[2] In 2010, 34 million people were estimated to be living with HIV worldwide. Two million seven hundred of these were new infections. AIDS related deaths were reported to be 1.8 million globally during the same period. Sub-Saharan Africa is the epicentre of the epidemic, with 22.9 million people reported to be infected with HIV in 2010. [3]

Zimbabwe, with an estimated population of 12.4 million, has a generalized HIV epidemic with a HIV prevalence reported to be 15% and incidence of 0.85.[4,5] This translates to around 1.2 million HIV infected people in the country. Such a high percentage of people living with HIV and AIDS in Zimbabwe means that the country is faced with a serious epidemic that has huge social and economic implications. In response to the pandemic, the government of Zimbabwe has established one national coordinating body, one national strategic plan, and one country monitoring and evaluation framework. This is in line with the “three ones” principle espoused by the World Health Organization (WHO) for cost-effective and sustainable interventions to the onslaught. Under this principle, the National AIDS Council (NAC) in Zimbabwe is responsible for coordinating the response in a multi-sectoral manner and for coordinating the country-level monitoring and evaluation system.

The monitoring and evaluation system in Zimbabwe was developed using the UNAIDS 12-component framework for developing a functional national M&E system. The main

objective of conducting monitoring and evaluation was to provide data to guide policy formulation and program operations. Many strategies have been put in place to stop the occurrence of new HIV infections. These strategies include the prevention of mother-to-child transmission (PMTCT), behaviour change strategies, and HIV treatment and counselling. HIV incidence is defined as the number of new HIV infections in the population during a certain time period. Incidence can be measured directly or indirectly. Direct methods include cohort studies and bioassays.

Direct methods are a gold standard. These methods, however, have some limitations in practice; for example, bioassays are too expensive, while cohort studies are costly and may take a long time to yield results. Many mathematical modelling techniques were developed for estimating HIV incidence and are now used worldwide to model the epidemic. These models include the workbook, ASSA model developed by the actuarial society in South Africa, Bayesian, Monte Carlo, and Incremental Mixture Importance Sampling (IMIS) models built in the Estimation and Projection Package (EPP), and the AIDS Impact Model (AIM) module in Spectrum developed by the UNAIDS reference group on estimates. Such methods have not been used in Zimbabwe to date. The application and use of such will be a major cost-cutting measure for the NAC of Zimbabwe.

II. Data

From the various co-indicators collected by NAC, data on antenatal clinic (ANC) attendance were used to estimate HIV prevalence in each district of Zimbabwe. The number of Adults on anti-retroviral (ART) drugs in each district was also used in estimating HIV incidence. All provinces and districts of Zimbabwe with ANC sites offering PMTCT services were included in the study. Provinces and districts with three consistent data points on HIV prevalence among women attending ANC were included in the analysis, whereas those with inconsistent data points were excluded. Routine HIV data collected by NAC for the period 2007 to 2010 were used in this study. The year 2007 was chosen because during this time, many districts were now offering PMTCT services in ANC. HIV data were grouped by province in Zimbabwe. The data were also grouped into 62 administrative districts in Zimbabwe as of the 2002 census. HIV data for women attending ANC for PMTCT in each province and in each district of Zimbabwe were extracted from the national HIV database at NAC.

Annual totals for women tested for HIV at ANC and totals of HIV positive pregnant women were calculated for each province and for each district of Zimbabwe for the period 2007 to 2010. Annual totals for each province and district for the period 2007 to 2010 were entered in Microsoft Excel. The data are checked for consistency and completeness. That is to say, the data were checked for validity, accuracy, usability, and integrity. Districts with at least three consistent HIV data points in the period 2007 to 2010 were considered for analysis, and districts with inconsistent data were dropped. ART program data were also extracted from the national HIV database. Annual totals for adults on ART in each province of Zimbabwe for the period 2008 to 2010 were calculated and entered into Microsoft Excel.

The number of ART clients on first-line ART was separated from those on second-line ART for each province. After data extraction from the NAC database was completed, the HIV data were organized into a Microsoft Excel spreadsheet. HIV prevalence for each province and district among women attending ANC for PMTCT services was calculated by dividing the number of women who tested HIV positive by those tested for HIV in the district antenatal clinics using MS Excel 2007.

III. Methods Used

EPP software was used for data analysis. The software uses a simple susceptible-infected-removed (SIR) epidemiological model that incorporates population change over time by fitting the four adjustable parameters r, t_o, f_o and ϕ, where r is the rate of infection, t_o is the start year of the epidemic, f_o is the initial fraction of the adult population at risk of infection, and ϕ is a behaviour change parameter. The output ρ is a sequence of yearly HIV prevalence rates. The model parameters have the following distributions;

- r Uniform [0, 15] [TM3] is the rate of infection, meaning that the average number of people an infected person infects per year can range from 0 to 15 times the fraction at risk.
- t_0 Discrete Uniform [1970; 1971, . . ., 1990] is the start year of the epidemic;
- f_0 Uniform [0,1] is the initial fraction of the adult population at risk of infection;
- ϕ Logistic (100, 50) is a behaviour change parameter.

The prior distributions of these parameters influence the shape of the epidemic. The fraction of the HIV negative population infected each year, or incidence, increases to a maximum and declines thereafter. When the number of new HIV infections is greater than the number of AIDS deaths, the prevalence rate increases. When incidence and mortality rates are almost equal, the epidemic peaks. After the peak, the prevalence rate declines because the number of AIDS deaths continues to increase due to the lag between becoming infected and dying of AIDS. When the number of new infections equals the number of deaths, an epidemic stabilizes.

When the rate of new infections is high, the prevalence increases faster at the beginning of the epidemic. The parameter f_o influences when and at what prevalence the epidemic peaks. If a higher proportion of the population is initially at risk, the epidemic will peak sooner and at a higher level. Changing t_o does not change the shape of the epidemic but can only change its timing. ϕ influences the level at which the epidemic levels off after the peak. Negative values of ϕ correspond to a situation in which new members of the population change their behaviour when they see others dying of AIDS, so that fewer of them enter the at-risk group. Positive values of ϕ correspond to a situation in which a larger fraction of new members enter the at-risk group. This could be due to pockets of the population that were previously isolated, perhaps by geography or culture, being exposed to infection [6].

In EPP, after creating the work set, defining the populations, entering HIV prevalence data, entering ART data, and HIV prevalence from the previous Demographic

and Health survey, the projection page or interface will appear as shown below. The projection page is organized into four areas;

a) Choosing what to fit**:** data are checked for the presence of outliers. If there are outliers, their effect will be assessed by comparing the graphs obtained after fitting the model to all data with those obtained after fitting to either the median or the mean. If there are outliers, the model is fitted using either the median or the mean, depending on the number of ANC sites in a province or district.

b) Determining how to fit the data: the parameters r, t_o, f_o, and ϕ are tested and assigned the ones that can vary freely. To allow an uptick or a stall in prevalence even after a sustained decline, an r stochastic model was proposed.[29] The r stochastic model allows the rate of infection to vary in time.

c) Level fits: if there is more than one sub-population in the work set, all sites are assumed to follow a similar epidemic curve, but they are allowed to be at different levels of HIV prevalence. The curves produced have the same shape, but higher-prevalence sites follow the upper curves, while lower-prevalence sites follow the lower curves.

d) Parameter panel: interactive exploration of the effects of changing the parameters on the statistical significance of the results. The statistical significance of the curves is measured by using the log-likelihood value. The log likelihood is colour-coded. If the background colour is green, then the curve is at the best fit. If r, t_o, f_o, and ϕ are further changed, and if the resulting curve is equivalent to the best fit curve, the background colour will change to yellow. If the curve is significantly worse than the best fit, the background will turn red.

The EPP model divides the population at time t into three groups: a not-at-risk group, X (t), an at-risk group, Z(t), and an infected group, Y(t). The model assumes a constant non-AIDS mortality rate μ and a constant fertility rate, and does not represent migration or age structure. The rate at which the sizes of the groups change is described by equations 1, 2, and 3:

$$\frac{dX(t)}{dt} = \left(1 - f\left(\frac{X(t)}{N(t)}, f_0, \varphi\right)\right)E(t) - \mu X(t), \quad [1]$$

$$\frac{dZ(t)}{dt} = f\left(\frac{X(t)}{N(t)}, f_0, \varphi\right)E(t) - \left(\mu + r\frac{Y(t)}{N(t)} + \lambda(t)\right)Z(t), \quad [2]$$

$$\frac{dY(t)}{dt} = \left(r\frac{Y(t)}{N(t)} + \lambda(t)\right)Z(t) - \int_0^1 \left(r\frac{Y(t)}{N(t)} + \lambda(t)\right)Z(t)g(t-\tau)d\tau, \quad [TM4] [3]$$

Where N (t)=X (t) + Z(t) + Y(t) is the total population, and g(τ) is the health death rate τ years after infection. Survival after infection is assumed to follow a Weibull (2.4, 12.8) distribution, implying a median survival time of 11 years. At the start of year t_0 of the epidemic, a fraction $\lambda(t_0) = 0.1\%$ of the at-risk group Z moves to the infected group Y. The population being modelled is aged over 15 years. The number of new members at time t, E(t), depends on the population size 15 years ago, the birth rate, and the survival rate from birth to age 15 years. When individuals survive to age 15 years, they are assigned to either the not-at-risk group, X (t), or the at-risk group, Z (t). The incidence at time t is defined by equation 4 below

$$\frac{dY(t)}{X(t)+Z(t)}. \quad [TM5] [4]$$

The Bayesian Melding approach was applied in the EPP model by first specifying a prior distribution of

$$\theta = (r, t_0, f_0, \varphi) \quad [6].$$

The UNAIDS reference group on estimates, modelling, and projections agreed on a default prior distribution. The observed ANC and national population-based survey data give the likelihood L(ρ) for the model output, using a hierarchical random effects model. Raftery and Bao (2009) developed a more efficient sampling strategy, incremental mixture importance sampling (IMIS), which was implemented in the EPP 2009 version of the EPP software. The Bayesian Melding procedure computes the posterior distributions using the sampling importance resampling (SIR) algorithm, with the first sample drawn from the prior distribution. This consists of simulating many samples from the prior distribution of the model parameters, weighting them by their likelihoods, and then re-sampling them with replacement using the computed weights. The SIR model does not work well for some countries. The IMIS was developed in place of SIR and works well in countries where SIR does not, for example, in Zimbabwe [7].

A. Incremental Mixture Importance Sampling (IMIS)

It is an iterative generalization of defensive mixture sampling importance sampling [7]. At each iteration, a multivariate normal distribution centred at the point with the highest importance weight is added to the current importance sampling distribution, which thus becomes a mixture of such functions and of the prior. The algorithm ends when the importance sampling weights are reasonably uniform, that is, when the expected fraction of unique points in the resample is at least

$$1 - 1/e = 0.632 \quad [8].$$

For the IMIS Algorithm, see Raftery, A.E. et al (2010) [7]. [TM6]

B. Assumptions of the EPP software

1) A median time from infection to death of 10.5 years for men and 11.5 years for women. The time from infection to eligibility and from eligibility to death was defined as the time from CD4 cell counts below 200 and below 350 cells/μl.

2) Average annual survival on ART is approximately 86% in the first year and 90% in subsequent years.

3) As ART coverage increases, the median CD4 cell count at ART initiation will rise, and first-year survival will also rise, nearing 95% as ART coverage nears 100%.

4) First-year survival depends on the baseline CD4 cell count.

5) Transmission from mother to child may be during pregnancy, during delivery, and through breastfeeding. Intrapartum transmission depended on the efficacy of various PMTCT regimens.

6) The probability of transmission through breastfeeding depends on the type and duration of breastfeeding. Mixed feeding has the highest risk, and mothers on ART to treat HIV have the lowest risk.

7) The ratio of fertility among HIV-infected women to fertility among HIV-uninfected women is above 1 for younger age groups (15–19 years) but below 1 for older HIV-infected women.

The above assumptions were made when estimating HIV incidence trends in the study. Since the assumptions were based on data from other settings and on national-level estimates, this could influence estimates for provinces and districts. The results obtained in EPP give an estimate of the number of new HIV infections and the percentage of the at-risk population getting infected per year. The number will be divided by the estimated number of people in the province or district for a particular year, then multiplied by 1000 to obtain the number of new infections per thousand people. Google Earth and Geographic Information Systems (GIS) were used to describe HIV incidence across Zimbabwe's provinces, showing the cumulative incidence for each province on the Zimbabwe map.

C. Ethics

Permission to use HIV data was received from NAC, and the permission letter was submitted to the institutional review board for ethical approval. Ethical approval was received from the appropriate ethical committees, JREC.

IV. Results

All ten provinces had at least three consistent data points. Of the 62 administrative districts, 59 had at least 3 consistent data points. Analysis was carried out on all ten provinces and 59 Districts in Zimbabwe. Available data (for the period 2007 to 2010) were used to calculate the actual cumulative incidence, that is, the sum of monthly totals for the rural and urban populations, province and district, for the period 2007 to 2010. Projections of cumulative incidence (for the period 2011 to 2015) were made using the EPP software using the assumptions stated above. EPP was developed for making short-term projections.

TABLE I. Table 1: Actual cumulative HIV incidence (per 1000 people) for the period 2007 to 2010

Area	2007	2008	2009	2010
Rural	12.53	12.61	12.68	10.65
Urban	11.27	11.6	11.63	9.87

The results in Table 1 show that HIV incidence cases remained high in rural areas compared to urban areas in the period 2007 to 2010. HIV incidence remained above 1% in rural areas and below 1% in urban areas in 2010. This may be because more people on ART live in urban areas than in rural areas. Many ART initiating sites are in urban areas compared to rural areas. Furthermore, many programmatic interventions are more easily accessible in urban areas than in rural areas. Generally, the incidence cases show a decreasing trend in both rural and urban. The trend in incidence in rural and urban areas cannot precisely give a clear picture of the state of the epidemic in all areas, as it may be wrongly generalized that all urban areas in Zimbabwe had a force of infection below 1% or all rural areas had a force of infection above 1% in 2010. The force of infection refers to the rate at which susceptible individuals become infected by HIV.

Therefore, there is a need to stratify incidence by province. The actual cumulative incidence by province for the period 2007 to 2010 is shown in Table 2.

TABLE II. Actual cumulative HIV incidence (per 1000 people) by province for the period 2007 to 2010

Province	2007	2008	2009	2010
Harare	8.77	8.91	9.03	8.03
Bulawayo	14.25	14.93	15.61	13.29
Midlands	12.06	12.63	13.03	12.05
Masvingo	10.97	11.13	11.64	9.68
Manicaland	9.52	9.91	10.26	8.91
Matabeleland South	16.63	16.99	17.34	14.71
Matabeleland North	12.25	12.61	12.95	10.66
Mashonaland Central	8.84	9.09	8.6	7.58
Mashonaland West	9.83	9.90	11.09	9.31
Mashonaland East	13.24	13.44	13.60	11.94

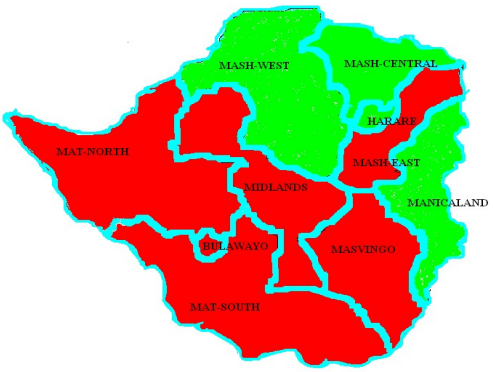
Actual cumulative HIV incidence remained below 1% from 2007 to 2010 in Harare and Mashonaland Central provinces. Cumulative incidence was also below 1% in the Mashonaland West and Manicaland provinces during 2007 to 2010, except in 2009, when the two provinces had a cumulative incidence above 1%. The other provinces had a cumulative incidence above 1% in the period 2007 to 2010. However, Table 2 shows a large apparent drop in the actual cumulative HIV incidence from 2009 to 2010.

The epidemic in Zimbabwe is also believed to be declining as a result of the impact of the prevention programmes, such as male circumcision [9]. Since 2009, Zimbabwe has provided circumcision to adult and adolescent men through a collaborative effort between the government and technical agencies to reach 1.2 million 15–29-year-olds by 2015 [10, 11]. The steady HIV-1 prevalence decline is also attributed to several factors, such as behaviour change, condom use, and high mortality rate of the infected [12, 13, 14]. The severe economic decline in the last decade has played a considerable role in sexual behaviour change, particularly partner reduction, particularly amongst urban men [15].

With the gross domestic product in Zimbabwe declining by about 40%, many men reported having less disposable income, and as such, their ability to purchase sex or maintain multiple sexual relationships was reduced [14, 16]. Decline could also be due to the early adoption of a home-based care

policy by the Zimbabwean government, which inadvertently accelerated behaviour change [9]. It has been hypothesized that when AIDS patients die at home, an experience that offers an opportunity among close family members and friends to have confrontation with AIDS morbidity and mortality, is more likely to instil fear of acquiring HIV/AIDS compared to a situation when they are primarily cared for in health institutions [17].

The distribution of HIV incidence for the period 2007 to 2010 by province is shown in the map in Figure 1.



Key

	Incidence above 2%
	Incidence below 1%

Fig. 3. Distribution of HIV incidence by province for the period 2007 to 2010

The map shows that HIV incidence is high in the southern and middle parts of the country. It appears there is a belt the epidemic follows. HIV incidence is high along the Great Dyke, which extends northeast to southwest across the centre of Zimbabwe. The belt has economically important metals such as chromium, nickel, copper, platinum, titanium, iron, vanadium, and tin. A lot of mining activities are happening along the great dyke. Mining areas are associated with high sexual activities, consequently high HIV transmissions in those areas. Provinces cut by the Great Dyke seem to have a high incidence, as shown on the map above, but we cannot generalize the size of the provincial incidence to all the districts in the province, as other districts may have an incidence well below 1% due to other factors. Incidence is also high in the border province, Matabeleland South. This may be due to large volumes of people migrating to South Africa, where the majority live in compounds, which is a risk factor for HIV transmission.

Table 3 classifies Zimbabwean districts by the size of the force of infection. 59 out of the 62 districts had data authenticated for analysis. Out of the 59 districts analysed, 11 had an actual force of infection above 2%, 43 had a force of infection between 1% and 2%, and only 5 districts had a force of infection below 1% in the period 2007 to 2010. Matabeleland South and North provinces had more districts with the highest force of infection, and this may be because the provinces share borders with South Africa and Botswana, and many people are migrating to these neighbouring countries looking for employment and may be exposed to more risk of contracting HIV.

TABLE III. CLASSIFICATION OF INCIDENCE BY DISTRICT FOR THE PERIOD 2007 TO 2010

Province	Incidence >2%	1%<incidence<2%	Incidence <1%
Harare		Harare	
Bulawayo	Bulawayo		
Midlands		Gweru Mberengwa Shurugwi Kwekwe Zvishavane Chirumanzu Gokwe North Gokwe South	
Masvingo		Chiredzi Bikita Chivi Gutu Masvingo Mwenezi Zaka	
Manicaland		Buhera Chipinge Makoni Mutare Mutasa Nyanga	Chimanimani
Mashonaland East	Seke Goromonzi	Chikomba Hwedza Marondera Mudzi Murehwa Mutoko UMP	
Mashonaland Central		Rushinga Shamva	Bindura,Guruve Mazowe, Mt Darwin
Mashonaland West		Kariba, Zvimba Kadoma Chegutu	Makonde Hurungwe
Matabeleland South	Umzingwane Insiza,Matobo, Beitbridge,Bulilima	Mangwe Gwanda	
Matabeleland North	Bubi Hwange Nkayi Umuguza	Tsholotsho Binga	Lupane

The EPP software not only gives current trends in HIV incidence, but it can also estimate future trends of HIV in the country. The data used were for the period 2007 to 2010, and incidence projections were made from 2011 to 2015. Table 4 below shows the estimated incidence by area of residence.

TABLE IV. PROJECTED CUMULATIVE INCIDENCE (FOR THE PERIOD 2011 TO 2015)

Area	2011	2012	2013	2014	2015
Rural	10.95	11.06	10.21	10.15	10.09
Urban	9.97	11.14	8.95	8.3	8.64

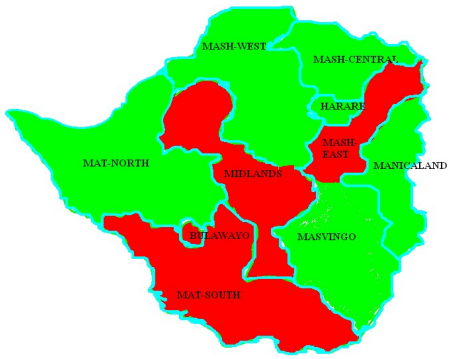
The force of infection is projected to decrease to less than 1% in urban areas and to remain above 1% in rural areas in the period 2011 to 2015. Scaling up ART and programmatic interventions will lower incidence in rural areas, as the epidemic shows a declining pattern.

TABLE V. PROJECTED CUMULATIVE HIV INCIDENCE (PER 1000 PEOPLE) BY PROVINCE FOR THE YEAR 2011 TO 2015

Province	2011	2012	2013	2014	2015
Harare	7.96	9.63	7.53	6.56	6.95
Bulawayo	15.16	14.62	15.80	16.04	19.55
Midlands	12.23	11.58	12.90	12.31	12.89
Masvingo	9.73	10.41	9.11	8.76	9.94
Manicaland	8.95	9.92	7.82	7.51	7.57
Matabeleland South	14.94	16.50	13.79	13.07	13.72
Matabeleland North	10.89	12.66	8.94	8.41	9.18
Mashonaland Central	9.29	9.51	6.18	5.32	5.57
Mashonaland West	10.40	8.87	8.53	8.05	8.33
Mashonaland East	13.19	12.43	11.79	11.46	12.57

Table 5 shows the cumulative HIV incidence (per 1000 people) by province for the years 2011 to 2015. Cumulative HIV incidence is estimated to decrease to less than 1% in six of the ten provinces in Zimbabwe (Harare, Masvingo, Manicaland, Matabeleland North, Mashonaland Central, and Mashonaland West) starting in 2013. The other four provinces (Bulawayo, Midlands, Matabeleland South, and Mashonaland East) are estimated to continue to have cumulative HIV incidence above 1% in the period 2011 to 2015. The following map shows the estimated future distribution of HIV incidence by province for the period 2011 to 2015. The provinces coloured in red had a force of infection above 1%, and those coloured in green had a force of infection below 1%. Also, the results in Table 5 above are shown on the map in Figure 2 below.

The provinces cut by the Great dyke are estimated to continue to have a force of infection above 1%. This may be due to the increased mining activities in the belt.



Key

	Incidence above 2%
	Incidence below 1%

Fig. 4. Distribution of HIV incidence by province for the period 2011 to 2015

TABLE VI. CLASSIFICATION OF INCIDENCE BY DISTRICT FOR THE PERIOD 2011 TO 2015

Province	Incidence >2 %	1%<incidence<2%	Incidence <1%
Harare			Harare
Bulawayo		Bulawayo	
Midlands		Mberengwa Shurugwi Kwekwe Zvishavane Chirumanzu Gokwe North Gokwe South	Gweru
Masvingo		Chivi Gutu Masvingo Mwenezi Zaka	Bikita Chiredzi
Manicaland		Chipinge Makoni Mutare Mutasa Nyanga	Chimanimani Buhera Nyanga
Mashonaland East		Chikomba Hwedza Marondera Mudzi Murehwa Mutoko UMP Seke Goromonzi	
Mashonaland Central		Rushinga Shamva	Bindura Guruve Mazowe Mt Darwin
Mashonaland West		Kariba Zvimba Chegutu	Makonde Hurungwe Kadoma Zvimba
Matabeleland South	Umzingwane Insiza Matobo Bulilima	Mangwe Gwanda Beitbridge	
Matabeleland North	Bubi Hwange Nkayi Umuguza	Binga	Lupane Tsholotsho

The classification of incidence by district for the period 2011 to 2015 is shown in Table 6 above. Umzingwane, Insiza, Matobo, Bulilima, Bubi, Hwange, Nkayi and Umuguza have Incidence greater than 2%, while Mberengwa, Shurugwi, Kwekwe, Zvishavane, Chirumanzu, Gokwe North, Gokwe South, Chivi, Gutu, Masvingo, Mwenezi, Zaka, Chipinge, Makoni, Mutare, Mutasa, Nyanga, Chikomba, Hwedza, Marondera, Mudzi, Murehwa, Mutoko, UMP Seke, Goromonzi, Rushinga, Shamva, Kariba, Zvimba, Chegutu, Mangwe, Gwanda, Beitbridge and Binga have incidence between 1% and 2%. Furthermore, Harare, Gweru, Bikita, Chiredzi, Chimanimani, Buhera, Nyanga, Bindura, Guruve, Mazowe, Mt Darwin Makonde, Hurungwe, Kadoma, Zvimba, Lupane and Tsholotsho have incidence less than 1%.

V. CONCLUSIONS

The force of HIV infection in Zimbabwe is expected to be the same in all areas, but it has been found in this research that HIV incidence in the country varies by geographical location. There is a difference in the force of infection

between rural and urban areas. The force of infection is still high in Matabeleland South, Midlands, Bulawayo, and Mashonaland East provinces. An increase in the use of ART reduces HIV incidence. Scaling up HIV counselling and testing activities in provinces or districts with high force of infection will help reduce the force of infection in these areas as the number of people on ART will increase.

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