Estimating Incidence of New HIV Infections In Uganda From Routine PMTCT Program Data

Abstract

We estimate annual prevalence and incidence of HIV by district in Uganda using routine data from the Prevention of Mother To Child Transmission (PMTCT) program, using methods previously reported in *Estimating Incidence of HIV with Synthetic Cohorts and Varying Mortality in Uganda*. District level estimates are not exact, but provide a relative ranking that reflects the general demand for treatment services. Using routine program data is faster and cheaper than population based surveys. In addition, it provides coverage for small geographic areas that are generally not available in population based surveys.

Methods

Uganda has PMTCT (Prevention of Mother to Child Transmission of HIV) program data from 2008 through 2013. Data for 2010 are for PEPFAR supported programs only, and are available only at the district level. All other years include a varying (though generally increasing) number of sites throughout Uganda, supported by other sources (such as the Uganda Ministry of Health or Global Fund) in addition to PEPFAR supported sites. Data for 2011 are highly inconsistent with all other years, both in magnitude and relative District impact. We estimate annual prevalence and incidence for each of these, using methods previously reported in *Estimating Incidence of HIV with Synthetic Cohorts and Varying Mortality in Uganda*.

Incidence is defined as the number of new cases occurring during a specified time period divided by the population at risk of acquiring an infection. Since HIV is presently not curable, a transition to HIV positive is a permanent state. Therefore, we can solve for an implied incidence by taking the difference in prevalent cases at two time points, and adding the number of deaths that occur to the starting HIV positive population during the time period. We treat each year of PMTCT data as representing a mid-year estimate of the prevalence, and we similarly estimate population totals for each year as of July 1 of that year. The population at risk is estimated as the average of the mid-year population at the two time points.

The mortality estimates are based on the post-ART mortality figures from the Masaka district cohort study[1]. It is also possible to assume mortality consistent with 100% ART coverage by using the estimates for the HIV negative population. Here we use the more conservative option

of the observed mortality in the post ART era for HIV positive individuals from the study. It is assumed that there is 66% ART coverage of eligible infected persons (CD4 counts less than 200), although this is not known for certain[1]. The actual level of coverage is not that important, what matters is that the national coverage is the same as the Masaka district cohort coverage. Again, this is not known for certain, but there is no reason to assume that national coverage differs from the coverage in Masaka.

The PMTCT data consists of counts of the number of pregnant women tested for HIV and the number that have positive tests (including women who were previously found to be HIV positive) by clinic site. This is referred to as unlinked anonymous testing, as the results are not linked to a specific individual. Since the PMTCT program data does not record age, we need to apply age distributions based on age specific survey estimates. In addition we need population counts in order to calculate incidence. We use the 2002 Uganda population Census data for women ages 15 to 49 by subcounty and 5-year age group for the population data[2]. We use the Demographic and Health Survey for Uganda 2011 to estimate age specific pregnancy rates, and we use the Demographic and Health Survey with HIV blood test results for six countries in the post ART era (Uganda 2011, Malawi 2010, Cameroon 2011, Kenya 2008/09, Mozambique 2009, Tanzania 2007/08)[3;4] for age distributions of HIV positive women, and pregnant HIV positive women.[*]

Table 1: Age Distribution of Pregnancy and HIV for Women 15 to 49

Age Group	Percent of Age Group Who Are Pregnant	Percent of HIV Positive Pregnant In Age Group	Percent of HIV Negative Pregnant In Age Group	Percent of Pregnant Women Who Are HIV Positive	Percent of Non-Pregnant Women Who Are HIV Positive	Percent of HIV Positive Women Who Are Pregnant
15 to 19	7.22	8.49	16.33	3.59	3.00	7.84
20 to 24	18.14	29.10	29.08	6.69	6.93	13.01
25 to 29	16.39	34.02	24.92	8.91	10.98	10.76
30 to 34	12.80	16.87	15.31	7.32	13.18	5.81
35 to 39	10.41	9.06	10.44	5.86	13.76	3.46
40 to 44	4.22	1.56	2.91	3.70	11.92	0.96
45 to 49	2.17	0.90	1.01	6.00	9.63	0.73
15 to 49	x.xx	100	100	6.69	9.10	6.73

Note that not only is the prevalence level different for pregnant women versus non-pregnant women (6.69 versus 9.10, overall HIV prevalence for women 15-49 is 8.88% (not shown)), so

[*] The number of observations of HIV positive pregnant women is relatively small (N=275 weighted), even for the combined surveys.

too is the age distribution. HIV positive pregnant women tend to be younger than the non-pregnant HIV positive women. This could be an effect of the duration of the disease lowering fertility levels for women, but this is not known for sure.

The district level count of women 15 to 49 is split between pregnant and non-pregnant based on the percentages in column 1 of table 1. The total number of pregnant women in each district is then split into a total HIV positive based on the district level total percent HIV positive from the PMTCT data. The total number of HIV positive women is then distributed to each age group based on the percentages in column 2 of table 1, and the HIV negative portion is distributed to each age group based on column 3 of table 1. In this manner we account for the differing age distributions of HIV positive and HIV negative pregnant women while also using the implied prevalence of the PMTCT data.

Once the district level population is distributed to the age groups, the mortality rates are applied to the HIV positive populations from year to year up to 2013. Incidence can then be solved for with demographic accounting. The number of incident cases that occur between the year of the PMTCT data and the subsequent year is the number of HIV positive cases in *t+1* minus HIV positive at time *t* plus number of deaths to HIV positive individuals during the time interval[†]. Negative incidence rates can occur when the estimated number of HIV positive cases in the starting time period is greater than the number at the end of the time period. This is usually the result of the end point estimates of prevalence being too low.

Incident rates are expressed as the number of incident cases per population at risk. The population at risk is the population that is HIV negative at the beginning time period. The total number of life years lived is calculated as the mid-point average population of the HIV negative count times the number of years lived. The incidence rate is the total incident cases divided by life years lived (in thousands).

The total count of prevalent cases can be calculated as the estimated count of HIV positive pregnant women in the age group divided by the proportion of HIV positive women who are pregnant, by age group. Summing across age groups yields an estimate of the number of women who are HIV positive. Dividing this count by the total number of women yields the estimated prevalence.

Table 2: Women 15 to 49

	Number of Women		HIV Positive			Prevalence	
Year	Women	Pregnant	Women	Pregnant	Deaths	Women	Pregnant

[†] This formula ignores individuals who become HIV+ and die within the interval. For short intervals this is unlikely to have much of an effect, but for longer intervals the effect is to under estimate the number of incident cases.

	Number of Women		HIV Positive			Prevalence	
Year	Women	Pregnant	Women	Pregnant	Deaths	Women	Pregnant
2008[‡]	6,236,127	720,640	731,064	49,192	30,170	11.72	6.83
2009[1]	6,463,457	745,107	686,854	46,217	28,345	10.63	6.20
2010	6,701,011	770,606	678,828	45,677	28,014	10.13	5.93
2011[§]	6,949,330	797,187	763,747	51,392	31,518	10.99	6.45
2012	7,209,716	824,983	669,154	45,026	27,615	9.28	5.46
2013	7,481,358	853,899	908,595	61,138	N/A	12.14	7.16

Table 2 is based on summing the underlying data to the national level. Results can differ when summing to sub-national levels and then aggregating the sub-national results to the national level. This happens when some sub-national areas (such as districts) do not have PMTCT data, either because there were no clinics during a particular time period or because they are not included in the reporting system at that time.

At the national level, the result is that estimates are higher than national surveys indicate. However, the utility of this method is to identify specific areas where incidence remains high. By ranking districts based on the estimated incidence, we can target interventions to areas that are most in need, even when the estimates appear incorrect.

Conclusions

Routine program data can provide informative relative rankings over extended time periods, but may not be entirely accurate as absolute measures. District level incidence rates estimated using routine program data provide the opportunity to obtain near real time monitoring of possible outbreak locations, and identify areas to concentrate interventions in.

(Add map here when ready)

[‡] Not all districts appear in 2008 and 2009 PMTCT data. Therefore, district level calculations for each year are based only on districts with PMTCT data.

[§] The UAIS estimate for women 14 to 49 in 2011 is 8.3%; for women 15 to 59 it is 8.2%

Table 3: Estimated Annual Incidence Rate, Ranked by 2012 Rate

Rates by District	Beginning Year									
	2012		2011		2010		2009		2008	
	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank
District Name										
KALANGALA	383.60	106	-761.88	1	644.45	98	450.38	72	371.77	77
KALUNGU	162.14	105	-99.11	5	64.39	88	.	.	.	.
PALLISA	114.73	104	-9.56	48	6.83	50	4.99	24	-18.24	23
KYENJOJO	112.17	103	-123.44	3	.	.	.	.	46.65	65
BUSHENYI	91.71	102	-56.38	13	-70.70	3	39.01	63	68.26	70
KANUNGU	91.41	101	-79.29	8	0.96	40	0.72	20	83.14	73
KABAROLE	90.44	100	-64.68	10	-115.93	2	175.31	71	75.24	71
RUKUNGIRI	88.47	99	-20.52	32	-32.07	6	39.44	64	-49.46	12
ADJUMANI	85.15	98	-11.27	45	7.06	52	-170.13	1	209.11	76
KATAKWI	84.90	97	-62.45	11	40.38	85	-9.59	10	-321.23	4
MUKONO	84.19	96	-4.69	57	-0.06	37	29.05	53	-8.02	28
KITGUM	83.65	95	-19.37	35	50.55	87	37.93	61	5.75	40
WAKISO	80.94	94	-15.33	39	-5.24	30	15.36	35	66.78	69
LIRA	79.26	93	-40.57	16	24.56	75	60.05	70	45.93	64
KABERAMAIDO	74.10	92	-23.18	27	29.17	81	-1.66	18	-348.65	3
LYANTONDE	73.64	91	-38.56	17	3.02	43	49.30	67	178.09	75
MASINDI	73.54	90	-31.13	24	31.31	82	25.01	47	37.46	58
MBALE	68.78	89	-32.84	20	15.38	64	25.96	48	6.87	43
LAMWO	66.76	88	-21.96	31	11.94	61	.	.	.	.
GULU	66.65	87	-35.04	18	17.93	67	23.11	46	38.49	60
BUKOMANSIMBI	66.17	86	45.79	102	-35.67	5	.	.	.	.
RAKAI	64.22	85	-19.83	33	-9.12	21	-41.32	4	32.56	55
GOMBA	60.05	84	-32.38	22	70.90	90	.	.	.	.
KAYUNGA	59.90	83	2.16	63	18.74	68	-1.72	16	63.43	67
NWOYA	58.61	82	-88.08	6	83.38	92	.	.	.	.
AMURIA	58.33	81	-22.53	30	21.47	71	6.53	25	8.26	44
BUDUDA	57.75	80	-11.84	44	-20.72	13	21.89	45	5.47	39

Rates by District	Beginning Year									
	2012		2011		2010		2009		2008	
	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank
JINJA	56.29	79	11.32	74	-8.31	22	8.15	27	1.88	37
BUKWO	56.13	78	20.81	86	-12.75	17	11.78	31	-2.97	33
LWENGO	54.76	77	18.60	83	12.99	62	.	.	.	.
MUBENDE	54.73	76	-4.15	58	48.33	86	14.20	34	4.71	38
BUDAKA	54.71	75	-0.12	61	14.57	63	0.96	21	1.80	36
NAKASEKE	53.88	74	-2.44	60	5.78	47	-8.95	11	54.05	66
LUWEERO	52.30	73	3.24	66	-7.71	24	28.76	52	-232.51	5
KABALE	51.77	72	-43.36	15	7.03	51	20.48	43	-4.60	32
MAYUGE	48.35	71	39.07	100	-5.60	27	17.67	40	6.30	42
KYANKWANZI	48.17	70	-55.15	14	35.50	83	.	.	.	.
BUNDIBUGYO	46.74	69	-8.41	50	.	.	.	.	-2.15	34
KIBUKU	45.73	68	8.43	73	1.04	41	.	.	.	.
KIBOGA	45.20	67	-83.92	7	95.29	95	37.41	60	-406.65	1
MOROTO	44.90	66	-15.04	40	-497.98	1	577.63	73	29.51	53
IBANDA	44.76	65	24.38	92	23.81	73	-0.63	19	-7.31	30
NGORA	44.30	64	-12.00	43	-30.44	7	.	.	.	.
SIRONKO	43.00	63	-19.79	34	10.29	58	16.54	36	-28.87	15
PADER	42.44	62	-25.17	25	75.95	91	-113.84	2	168.20	74
TORORO	41.61	61	15.87	79	-3.82	33	10.52	29	-36.29	14
SOROTI	41.31	60	-32.43	21	10.00	57	30.50	56	-8.00	29
KAMULI	40.55	59	-15.37	38	6.78	49	4.03	23	65.57	68
MOYO	39.36	58	-22.81	28	7.87	55	17.16	39	-14.80	25
YUMBE	38.38	57	-5.18	56	9.93	56	-4.04	13	-39.03	13
AMURU	37.87	56	-14.95	41	21.73	72	7.80	26	8.79	45
ISINGIRO	35.93	55	8.28	72	7.52	54	8.24	28	-20.94	22
NTOROKO	35.66	54	-31.45	23	.	.	.	.	.	.
KYEGEGWA	35.20	53	4.44	68	.	.	.	.	.	.
OTUKE	34.82	52	52.77	103	-3.02	35	.	.	.	.
APAC	34.76	51	-10.38	47	3.77	44	28.44	51	28.23	52

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	2012		2011		2010		2009		2008	
	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank
KIRUHURA	34.08	50	19.26	85	-5.40	28	31.27	57	42.32	62
KAPCHORWA	34.02	49	23.36	90	-7.87	23	29.62	55	-160.26	6
KIBAALE	33.77	48	18.21	82	.	.	.	.	40.35	61
AGAGO	33.74	47	-3.96	59	-7.70	25	.	.	.	.
KASESE	33.46	46	17.09	81	36.27	84	-51.36	3	23.99	49
NAKASONGOLA	33.39	45	-6.28	53	26.34	78	-6.36	12	-26.04	17
NAKAPIRIPIRIT	32.68	44	-60.17	12	.	.	.	.	-96.33	8
NAMAYINGO	32.41	43	-7.29	52	24.21	74	.	.	.	.
SERERE	30.16	42	-15.40	37	-4.93	31	.	.	.	.
BUKEDEA	29.48	41	-24.09	26	25.17	76	-21.15	8	37.63	59
KUMI	29.35	40	-6.08	54	-10.35	20	18.86	42	12.73	46
BUTAMBALA	29.17	39	22.08	89	27.32	79	.	.	.	.
BULIISA	27.98	38	33.40	97	0.73	39	37.02	59	25.28	51
MASAKA	23.91	37	5.73	69	26.08	77	16.90	37	-69.02	11
BULAMBULI	23.50	36	21.54	88	-2.81	36	.	.	.	.
MANAFWA	23.38	35	14.12	78	0.25	38	-1.72	15	-0.11	35
KIRYANDONGO	20.66	34	-5.56	55	18.96	69	.	.	.	.
NEBBI	19.97	33	29.83	95	-5.76	26	-15.35	9	-8.56	27
HOIMA	18.02	32	2.43	64	1.81	42	31.46	58	17.74	47
DOKOLO	17.03	31	-7.98	51	-3.06	34	55.25	68	36.59	57
ARUA	16.06	30	20.98	87	7.41	53	-32.36	6	31.64	54
ZOMBO	15.47	29	33.03	96	-25.53	9	.	.	.	.
BUIKWE	15.05	28	-9.44	49	20.61	70	.	.	.	.
KAMWENGE	14.73	27	7.45	71	15.93	65	17.07	38	-23.67	18
OYAM	14.66	26	-10.62	46	28.04	80	12.35	32	5.85	41
MITOOMA	12.96	25	-22.78	29	4.97	46	.	.	.	.
KALIRO	12.58	24	4.05	67	-23.37	10	41.41	65	-93.91	9
MBARARA	12.57	23	-70.27	9	68.85	89	-1.71	17	43.87	63
NAMUTUMBA	11.10	22	-14.22	42	-5.28	29	26.46	49	24.38	50

Rates by District	Beginning Year									
	2012		2011		2010		2009		2008	
	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank	Incidence Per 1,000 LY	Rank
NTUNGAMO	10.64	21	27.38	94	-11.87	18	13.86	33	34.65	56
BUSIA	10.23	20	19.22	84	-23.06	11	27.90	50	-17.07	24
SSEMBABULE	10.21	19	99.47	106	-36.30	4	-21.87	7	78.21	72
BUGIRI	9.55	18	12.51	76	6.71	48	-37.62	5	22.74	48
NAPAK	9.42	17	6.30	70	.	.	.	.	.	.
KWEEN	7.52	16	16.03	80	-4.65	32	.	.	.	.
KAMPALA	4.74	15	-34.22	19	84.46	93	18.68	41	-21.27	21
MARACHA	1.44	14	-108.53	4	168.66	96	1.65	22	-350.31	2
LUUKA	0.67	13	2.68	65	-10.90	19	.	.	.	.
BUVUMA	0.23	12	-15.46	36	87.65	94	.	.	.	.
AMOLATAR	-1.52	11	-263.39	2	326.65	97	29.25	54	-21.34	20
MPIGI	-2.59	10	63.12	105	11.30	60	45.90	66	-5.11	31
BUYENDE	-2.84	9	43.21	101	-13.86	16	.	.	.	.
BUTALEJA	-2.93	8	0.35	62	10.84	59	-3.21	14	-22.49	19
KOBOKO	-4.01	7	11.48	75	-15.12	15	11.07	30	-81.94	10
IGANGA	-4.25	6	13.34	77	-26.18	8	55.99	69	-8.77	26
AMUDAT	-11.23	5	23.53	91	.	.	.	.	.	.
KISORO	-16.52	4	25.24	93	-21.23	12	21.58	44	-26.20	16
ALEBTONG	-21.77	3	38.05	99	4.38	45	.	.	.	.
KOLE	-22.97	2	34.35	98	16.70	66	.	.	.	.
MITYANA	-25.78	1	55.47	104	-18.37	14	38.70	62	-102.97	7

Reference List

(1) Kasamba I, Baisley K, Mayanja BN, Maher D, Grosskurth H. The impact of antiretroviral treatment on mortality trends of HIV-positive adults in rural Uganda: a longitudinal population-based study, 1999-2009. *Trop Med Int Health* 2012;17:e66-e73.

(2) Uganda Bureau of Statistics. Uganda In Figures, 2013. 1-62. 8-1-2013. Kampala, Uganda, UBOS.
Ref Type: Online Source

(3) Uganda Bureau of Statistics, ICF International. Uganda Demographic and Health Survey 2011. 7-1-2012. Kampala, Uganda and Calverton, Maryland.
Ref Type: Report

(4) Ministry of Health, ORC Macro. Uganda HIV/AIDS Sero-behavioural Survey 2004-2005. 7-1-2006. Calverton, Maryland.
Ref Type: Report