Estimating Incidence of HIV with Synthetic Cohorts and Varying Mortality in Uganda

Abstract

We estimate the incidence of HIV using two cross-sectional surveys in Uganda with varying mortality rates. The introduction of Anti-Retroviral Therapy (ART) in Uganda in 2004 has significantly increased the life span of those infected with HIV. The increase in lifespan has the result of increasing the prevalence level in the 2011 DHS. We show that incidence can be estimated under varying assumptions of ART coverage and just how much of the prevalence is a function of the increase in lifespan due to the use of ART.

Introduction

Current HIV surveillance systems such as the Demographic and Health Surveys (DHS) only generate measures of prevalence, usually for a small number of cross classification attributes such as sex, age, geographic region and urban/rural place of residence. It is desirable to have a measure of incidence (rate of new infections) in order to better monitor the ongoing HIV epidemic. Incidence provides information about the ongoing risk of infection, and may indicate where resources should be concentrated in order to slow or stop the epidemic.

Several methods have been proposed to measure the incidence of HIV where multiple cross sectional surveys are available for the same general population separated by some time interval. All methods require assumptions regarding the mortality of HIV infected individuals. Hallett, et.al. show two variations for estimating mortality, both of which assume no use of ART. In addition, the methods demonstrated by Hallett assume that the time between surveys and the age interval reported are equal. We propose an additional measure of mortality that utilizes cohort mortality both before and after the introduction of ART. In addition, we use estimates based on single years of age to allow varying intervals between surveys, and to allow the use of the models with program reporting data (such as antenatal clinic data), which is typically reported every six months.

Methods

Data

We use two successive DHS AIDS Indicator Surveys (AIS) for Uganda, 2004/5 and 2011, and cohort mortality data from the Masaka district study. In addition, we have population count data by sex and single year of age for each subcounty. The population count data is forecasted from the 2002 Uganda Census.

The Uganda DHS AIS for 2004 was conducted between August 2004 and January 2005. In terms of the cumulative number of surveys conducted over this time period as measured by households, the mid-point is October 2004. The 2011 survey was conducted between February 2011 and September 2011 with a mid-point of May 2011. The interval between the mid-points of the surveys is 6.6 years. We round this to seven years in our calculations, to correspond with single years of age. These surveys have two difficulties associated with age – age miss-reporting and (in particular in 2011) not matching the population age distribution. In looking at the distribution of age in single years, it is quite apparent that an excess number of observations fall on ages ending in 2 (halfway between 0 and 4) and 7 (likewise halfway between 5 and 9). Whether this reflects actual reporting by individuals or “estimating” by interviewers is unknown. In order to partially correct for the difference in age distribution, we post-stratify the sampling weights to estimated population counts, by sex, region, type of place of residence, and five year age groups. This also allows us to more easily obtain population counts. We also use a spline and knot model to smooth out the variation in prevalence by age which is then applied to a logistic model to estimate adjusted prevalence by sex and type of place of residence.

The DHS data includes information on sexual activity, some of which is related to life time sexual activity. However many of the questions concentrate on sexual activity over the previous 12 months: number of partners; was a condom used; was alcohol involved; was money (or goods) exchanged for sex. We use a combination of these variables plus some basic demographic data in our model of HIV prevalence. Although significance does vary for many of the variables, we use the same models for each of our four groups.

The table shows the logit results for the four models. Age is transformed with a spline and knot model, and the number and location of the knots is allowed to vary for each model. Interestingly, this transformed age variable is the only coefficient that is remotely significant in all four models. Region is both larger and more significant for females than males. Education is significant for three groups, but not rural females. The indicator for transactional sex in the previous 12 months is significant for urban males and rural females, while the indicator for multiple partners (which has a sex specific definition) is significant for all but urban males.

Table: Logit Estimate of HIV by Sex and Type of Residence, Uganda 2004 and 2011 Combined

	Urban – Males Coefficient (p-value)	Rural – Males Coefficient (p-value)	Urban – Females Coefficient (p-value)	Rural – Females Coefficient (p-value)
Intercept	-6.04 (0.00)	-5.50 (0.00)	-4.38 (0.00)	-4.28 (0.00)
Region				
Central/Kampala	-0.53 (0.13)	0.32 (0.02)	-0.66 (0.00)	0.05 (0.65)
East Central	-0.11 (0.81)	-0.22 (0.22)	-0.59 (0.00)	-0.58 (0.00)
Mid Eastern	-0.47 (0.35)	-0.39 (0.08)	-0.63 (0.02)	-0.90 (0.00)
North East	-0.27 (0.63)	-0.10 (0.55)	-1.01 (0.00)	-0.73 (0.00)
West Nile	0.04 (0.94)	-0.03 (0.84)	-0.31 (0.24)	-0.43 (0.01)
West	Ref (NA)	Ref (NA)	Ref (NA)	Ref (NA)
Age-Transformed	0.09 (0.00)	0.06 (0.00)	0.05 (0.00)	0.04 (0.00)
Education				
Primary	0.94 (0.00)	0.53 (0.02)	1.09 (0.00)	0.31 (0.25)
Secondary	0.83 (0.00)	0.43 (0.08)	0.56 (0.01)	0.28 (0.30)
University	Ref (NA)	Ref (NA)	Ref (NA)	Ref (NA)
Transactional Sex	1.23 (0.01)	0.29 (0.47)	0.37 (0.27)	0.80 (0.00)
Multiple Partners	0.09 (0.66)	0.61 (0.00)	0.91 (0.00)	0.89 (0.00)

These models yield predicted values of HIV for the data. We obtain average values for each year of age for each of the four groups, and apply that predicted value to the population count to get predicted population counts of HIV infection. The models clearly smooth out the distribution over age, but some still have increases at the oldest age groups, particularly in the urban setting.

(Insert graphs here)

Detailed information for the Masaka cohort study is available elsewhere (insert citations). In brief, the Masaka district cohort is a general population cohort study established in 1989 in rural south-west Uganda. It includes about 20,000 individuals from 25 neighboring villages near Lake Victoria (in the area where the Ugandan epidemic is thought to have started). Most of the participants are subsistence farmers and are distributed throughout the countryside rather than in villages. ART was introduced in 2004 and is believed to cover 66% of the eligible population (those with CD4 counts below 200). Detailed mortality data is available by age (five year age groups) sex and HIV status (but not individual ART status) for the ten year time period of 1999 to 2009. This allows for a five year follow-up both before and after the introduction of ART. The two DHS surveys are conveniently timed to largely correspond to the introduction of ART and after seven years of population level treatment.

(Insert table of mortality here)

Uganda last conducted a population census in 2002, which includes counts of people by sex and single year of age for each subcounty. The Uganda Bureau of Statistics (UBOS) provides a forecast of the population counts by district for 2011. We apply exponential growth rates between 2002 and 2011 to get annual growth rates by district, which we apply at the subcounty level to get population forecast corresponding to the time points associated with the two DHS surveys (October 2004 and May 2011). Subcounty is the geographic level at which an urban designation is determined. As HIV rates differ by urban/rural status (particularly for females) we create estimates accounting for type of place of residence. Only about 13% of the population lives in an urban area.

The population in Uganda has a very young age structure, both from early mortality and a high birth rate. The expectation of life at birth is 48.8 for males and 52.0 for females, based on results from the 2002 Census (insert citation from web). The estimated total fertility rate is 6.2, based on the 2011 Uganda DHS survey.

Models

Our objective in modeling HIV prevalence is to obtain a smooth predicted value that we can apply to the population counts in order to estimate the number of individual with HIV. Consequently, we do not attempt to exhaustively explain the significance of every variable in our models or why they may be significant for one group but not another. We are primarily concerned with the prediction by age that the models give us. Consequently we look initially at where HIV prevalence varies by sex and include those variables in our final models. We model HIV prevalence separately for males and females by type of place of residence, since urban females in particular have a higher prevalence than males and rural females. In addition, rates vary by region to some degree. Our final models consist of the transformed age variable, a six category region variable, an education indicator, whether an individual had engaged in transactional sex, and a sex specific dummy for multiple partners.[1] We end up with a three category education variable that indicates completion of primary, secondary or a university education. Transactional sex is defined as having exchanged money or goods for sex within the previous 12 months.

Our analysis indicates that the impact of the lifetime number of partners on HIV status is sex specific. We end up with a dichotomous variable indicating six or more partners for men and two or more partners for women.

In order to estimate incidence from the two prevalence rates, we need a model of mortality for HIV positive individuals. In analyzing the mortality data we find no difference in mortality rates by sex for the HIV positive group, but there is a difference for the HIV negative group. Therefore, we estimate age smoothed mortality rates for four groups: HIV negative males; HIV negative females; HIV positive pre-ART; and HIV positive post-ART. Although the data are for five year age intervals, we assume that the deaths are evenly distributed within the five year interval and create predicted mortality estimates for single years of age using a Poisson model with a log link.

Table: Regression estimates for mortality

	HIV Negative Males		HIV Negative Females		HIV Positive Post-ART		HIV Positive Pre-ART	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Intercept	-7.5	<0.0001	-6.9	<0.0001	-3.7	<0.0001	-3.2	<0.0001
Age	0.059	<0.0001	0.0376	<0.0001	0.0143	0.1027	0.0285	<0.0001

Interestingly, age is not particularly significant in the era of ART treatment ($p=0.10$). Average predicted mortality rates from these models are applied to population count data to determine the number of HIV positive individuals dying each year in the interval 2004 to 2011.

Results

(These are the estimates with both surveys combined) We show the unadjusted results for both the cohort analysis and the period analysis for the four age/place of residence groups. Using a seven year interval between surveys, we age the synthetic cohort seven years. Thus the age group 15 to 19 in 2004 ages to 22 to 26 in 2011, etc. One result of this is that the youngest age cohort does not exist in 2011, as the DHS surveys include only people aged 15 to 59 at the time of the survey. Overall unadjusted estimates indicate a slight drop in prevalence for urban males and urban females and a slight increase

[1] The variables concerning condom use appear to either be not a good indicator for HIV status or a poor estimator of condom use (or both) so they are not included in the model. It is possible that condom use (or lack thereof) could be a good indicator of who will become infected, but may not be a good indicator of current infection. This could arise as a consequence of behavioral change that has taken place in the recent past and thus may not impact current estimates as much as future estimates.

for rural males and rural females overall. For both males and females, the unadjusted urban estimates show much greater variability by age, with corresponding larger confidence intervals. The models smooth out some of the variability, but it remains higher for the urban estimates than the rural estimates. Although the DHS is designed to yield estimates for urban dwellers, the sample sizes are much smaller (urban is about ¼ the size of rural for males and 1/3 for females).

Urban Males

Viewing the unadjusted estimates as aged cohorts, we see prevalence increasing as urban males age from 15 to 29 into the 22 to 36 age groups. Then prevalence basically evens out for ages 30 and above in 2004 at a prevalence around 14%, with one upward spike for the age group 40 to 44 in 2004 (although with a very large confidence interval). Prevalence begins dropping at age 45, where mortality probably takes over. In 2011, a similar, but slightly lower pattern is observed. Combining the two surveys (as is done in the graph) but showing the estimates for single years of age reveals how unstable the estimates are, particularly for urban areas. The confidence intervals for the urban estimates are so large that it necessitates scaling the graphs to 80%, as compared to 30% for the rural estimates.

Table: Unadjusted Prevalence of HIV Among Urban Males by Age Group, 2004 and 2011

Age 2004	Prevalence (95% C.I.)	Cohort Age	Prevalence (95% C.I.)	Age 2011	Prevalence (95% C.I.)
15 to 19	0.2 (0.0 - 1.6)	22 to 26	4.4 (2.2 - 8.7)	15 to 19	0.3 (0.0 - 2.3)
20 to 24	4.7 (2.3 - 9.5)	27 to 31	7.4 (4.6 - 11.6)	20 to 24	2.9 (1.2 – 6.8)
24 to 29	4.7 (2.8 - 7.9)	32 to 36	9.9 (6.3 - 15.2)	25 to 29	4.2 (2.2 – 7.9)
30 to 34	13.7 (7.2 - 24.5)	37 to 41	12.0 (7.4 - 19.0)	30 to 34	11.4 (7.5 – 17.0)
35 to 39	17.9 (10.7 - 28.6)	42 to 46	13.8 (7.3 - 24.6)	35 to 39	8.6 (5.4 – 13.3)
40 to 44	11.6 (5.4 - 23.3)	47 to 51	16.4 (4.5 - 45.1)	40 to 44	16.8 (9.8 – 27.2)
45 to 49	20.9 (11.1 - 35.9)	52 to 56	15.2 (5.1 - 37.5)	45 to 49	17.4 (7.0 – 37.0)
50 to 54	7.2 (2.1 - 22.2)	57 to 59	15.5 (2.2 - 59.4)	50 to 54	5.9 (2.3 – 14.4)
55 to 59	10.4 (3.8 - 25.5)			55 to 59	22.1 (8.2 – 47.2)
Total	7.3 (5.3 - 9.9)			Total	6.1 (4.8 – 7.7)

Rural Males

The pattern for rural males shows a more traditional epidemic curve, with a leveling off of prevalence beginning about age 36, and a declining prevalence beginning around age 42. However, the unadjusted estimates show greater variability at older ages, probably reflecting age miss-reporting as sample sizes are similar across age groups.

Table: Unadjusted Prevalence of HIV Among Rural Males by Age Group, 2004 and 2011

Age 2004	Prevalence (95% C.I.)	Cohort Age	Prevalence (95% C.I.)	Age 2011	Prevalence (95% C.I.)
15 to 19	0.3 (0.1 – 0.8)	22 to 26	2.8 (1.9 – 4.1)	15 to 19	2.0 (1.3 – 3.0)
20 to 24	2.1 (1.3 – 3.4)	27 to 31	5.8 (4.2 – 8.0)	20 to 24	2.9 (2.0 – 4.2)
24 to 29	6.1 (4.5 – 8.3)	32 to 36	10.0 (8.0 – 12.5)	25 to 29	4.1 (2.8 – 5.9)
30 to 34	7.6 (5.8 – 9.9)	37 to 41	10.6 (8.6 – 13.1)	30 to 34	8.5 (6.6 – 10.9)
35 to 39	8.7 (6.5 – 11.7)	42 to 46	10.0 (7.8 – 12.7)	35 to 39	10.7 (8.5 – 13.4)
40 to 44	9.5 (7.1 – 12.7)	47 to 51	8.4 (5.7 – 12.2)	40 to 44	10.1 (8.0 – 12.6)
45 to 49	5.6 (3.8 – 8.3)	52 to 56	5.9 (3.7 – 9.1)	45 to 49	10.1 (7.8 – 13.0)
50 to 54	6.5 (4.3 – 9.9)	57 to 59	5.1 (2.6 – 9.5)	50 to 54	6.9 4.1 – 11.2)
55 to 59	5.6 (3.3 – 9.3)			55 to 59	4.4 (2.4 – 7.9)
Total	4.6 (4.0 – 5.3)			Total	5.5 (4.9 – 6.2)

Urban Females

Urban females show a higher prevalence across all age groups than rural females, with a peak prevalence of 26% for the 30 to 34 age group in urban areas, as opposed to a peak prevalence of 10.7% for rural females in the same age group. Overall prevalence is 13.2% as opposed to 6.3%. Prevalence is consistently higher for urban females across all age groups. It is possible that this reflects internal migration of HIV positive women who move to urban areas seeking better care, possibly after they become widowed. However this is only known anecdotally and whether there is enough of this migration to impact the estimates is unknown. Estimates by single year of age show a great deal of variability, probably reflecting age miss-reporting. In addition, the estimates for urban females show an uncharacteristic increase at older ages (over 55) which is strong enough to remain even in the adjusted estimates.

Table: Unadjusted Prevalence of HIV Among Urban Females by Age Group, 2004 and 2011

Age 2004	Prevalence (95% C.I.)	Cohort Age	Prevalence (95% C.I.)	Age 2011	Prevalence (95% C.I.)
15 to 19	4.2 (2.4 – 7.1)	22 to 26	8.1 (5.4 – 11.9)	15 to 19	3.2 (1.7 – 5.9)
20 to 24	11.4 (2.4 – 7.1)	27 to 31	13.6 (10.4 - 17.6)	20 to 24	8.1 5.7 – 11.2)
24 to 29	15.6 (12.0 – 20.1)	32 to 36	21.0 (14.8 – 28.9)	25 to 29	12.1 (9.2 – 15.9)

30 to 34	26.0 (19.0 – 34.3)	37 to 41	17.7 (11.9 – 25.6)	30 to 34	14.7 (0.8 – 19.7)
35 to 39	19.5 (13.2 – 27.7)	42 to 46	16.3 (9.4 – 26.8)	35 to 39	24.0 (7.2 – 32.5)
40 to 44	22.8 (12.7 – 37.6)	47 to 51	10.3 (5.6 – 18.0)	40 to 44	13.1 (8.3 – 20.3)
45 to 49	16.7 (9.6 – 27.4)	52 to 56	10.4 (4.5 – 22.0)	45 to 49	14.1 (7.7 – 24.3)
50 to 54	10.4 (3.9 – 25.2)	57 to 59	20.1 (6.0 – 50.0	50 to 54	13.5 (7.2 – 23.8)
55 to 59	2.9 (0.4 – 18.6)			55 to 59	11.3 (3.2 – 33.0)
Total	13.2 (11.7 – 14.9)			Total	10.4 (9.1 – 11.8)

Rural Females

Rural females have lower prevalence across all ages than urban females. There is somewhat less variability in the estimates, though it is still high, probably reflecting age miss-reporting. Although the trend across ages generally shows a normal epidemic curve (similar to the estimates for urban females) it does show an increase at older ages. This may also be the result of age miss-reporting.

Table: Unadjusted Prevalence of HIV Among Rural Females by Age Group, 2004 and 2011

Age 2004	Prevalence (95% C.I.)	Cohort Age	Prevalence (95% C.I.)	Age 2011	Prevalence (95% C.I.)
15 to 19	2.3 (1.6 – 3.4)	22 to 26	7.4 (5.9 – 9.2)	15 to 19	2.9 (2.1 – 3.9)
20 to 24	5.5 (4.2 – 7.2)	27 to 31	9.7 (8.0 – 11.6)	20 to 24	6.6 (2.9 – 3.1)
24 to 29	7.8 (6.1 – 9.8)	32 to 36	9.4 (7.6 – 11.5)	25 to 29	9.0 (7.5 – 10.9)
30 to 34	10.7 (8.9 – 12.8)	37 to 41	11.5 (9.1 – 14.3)	30 to 34	9.7 (7.5 – 10.9)
35 to 39	9.1 (7.1 – 11.5)	42 to 46	10.1 (7.9 – 12.9)	35 to 39	10.3 (8.3 – 12.7)
40 to 44	7.2 (5.5 – 9.5)	47 to 51	8.3 (6.3 – 10.9)	40 to 44	10.2 (8.2 – 12.7)
45 to 49	6.9 (4.9 – 9.7)	52 to 56	5.9 (4.0 – 8.7)	45 to 49	10.6 (8.4 – 13.2)
50 to 54	5.1 (3.3 – 7.6)	57 to 59	5.7 (2.9 – 11.0)	50 to 54	6.5 (4.4 – 9.4)
55 to 59	5.0 (2.9 – 8.7)			55 to 59	5.2 (3.2 – 8.3)
Total	6.3 (5.6 – 7.1)			Total	7.4 (6.7 – 8.1)

Life table based incidence estimates

Using the modeled prevalence and mortality estimates, we create estimates of incidence using demographic accounting. The underlying models use population data for single years of age by sex and subcounty, however we report the results in five year age groups. The age groups for the 2004 data start at 15 to 19, etc., up to 55 to 59. These groups are then aged seven years to 2011. One shortcoming of using the DHS data is that we do not have full estimates for the youngest age group at the second point in time (2011) because only persons aged 15 through 59 are tested. Therefore the estimate for 12 to 16 year olds actually has only 15 to 16 year olds in the numerator. We assume that the prevalence for those under 15 is zero.

Our mortality data allows us to estimate the number of deaths we expect for the HIV positive population under two scenarios – 0% ART coverage (based on the 1999-2003 data) and 66% ART coverage (based on the 2004-2009 data), where the percentage of coverage is based on those with CD4 cell counts under 200[2]. This allows us to estimate both the deaths averted due to ART and what the prevalence would have been without ART. The estimates for all males combined (rural and urban) indicate an overall prevalence of 5.6% using the post-stratified sampling weights. Applying the model estimates to the 2011 population yields a prevalence of 4.5%, and 5.3% for 2004. The estimates for 2011 exclude those who died in the interval (both those who were HIV positive in 2004 and those who sero convert and die). By adding the deaths under each of the scenarios to the number of persons who are HIV positive in 2011, then subtracting the number who are HIV positive in 2004, we get an estimate of the total incidence for the seven years. One result of this is that we can end up with negative numbers on occasion. In these instances, we assume zero incidence. We further assume that the 2004 prevalence for the youngest age group is zero, thus all 2011 cases are incident cases.

For males, we end up with an estimated 188,334 cases under the 66% ART scenario, for an implied prevalence of about 27,000 cases per year (4.15 per 1,000 PY). Under the assumption of 0% ART, we have 274,017 implied incident cases in total, or 39,145 per year (6.04 per 1,000 PY). Total deaths averted due to ART is estimated to be a bit over 99,000 in total. The prevalence estimate in 2011 without ART (where all the deaths averted are subtracted from the observed cases in 2011) is 3.3%, as compared to 4.5% with ART. Thus nearly 27% of the observed prevalence for males is due to the impact of ART.

(Insert Estimated Incidence table here)

Discussion

The difference between the 2011 unadjusted male estimate of HIV prevalence of 5.6% and the adjusted estimate of 4.5% (both using the post-stratified weights) is disconcerting. It is possible that it has to do with urban/rural differences, and that both estimates should be place of residence specific, although the adjusted estimates include place of residence. However the difference for 2004 is much smaller and in

[2] Regardless of what the coverage actually is, the mortality estimates reflect the level of coverage observed in the Masaka district study, which is believed to reflect coverage of the population as a whole. Thus the actual level is not important, but whether the study area and the population as a whole are equal is important.

the opposite direction – 5.0% versus 5.3%. The estimate for all males using the original sampling weights in the DHS is 6.1% in 2011 and 5.2% in 2004, further indicating that the age distribution in the 2011 sample is not a particularly good representation of the age distribution in the population.

Given reasonable mortality information for persons with HIV and population projections, it is possible to estimate incidence from multiple prevalence surveys. However if mortality rates are high and the population projections already account for the mortality, it is possible that the population projections will need to be adjusted for changes in mortality. This will occur when prevalence levels are high (how high??) and the impact of ART on mortality is substantial.

If the population estimates are sufficiently detailed with regard to age and geography, these models can be used with program data that is collected on an annual or semi-annual basis such as prevalence rates from antenatal clinics (ANC) to serve as a potential early warning device.

Table: Mortality – Masaka, Uganda District Study, 1999 through 2009

HIV-positive, Deaths and person-years

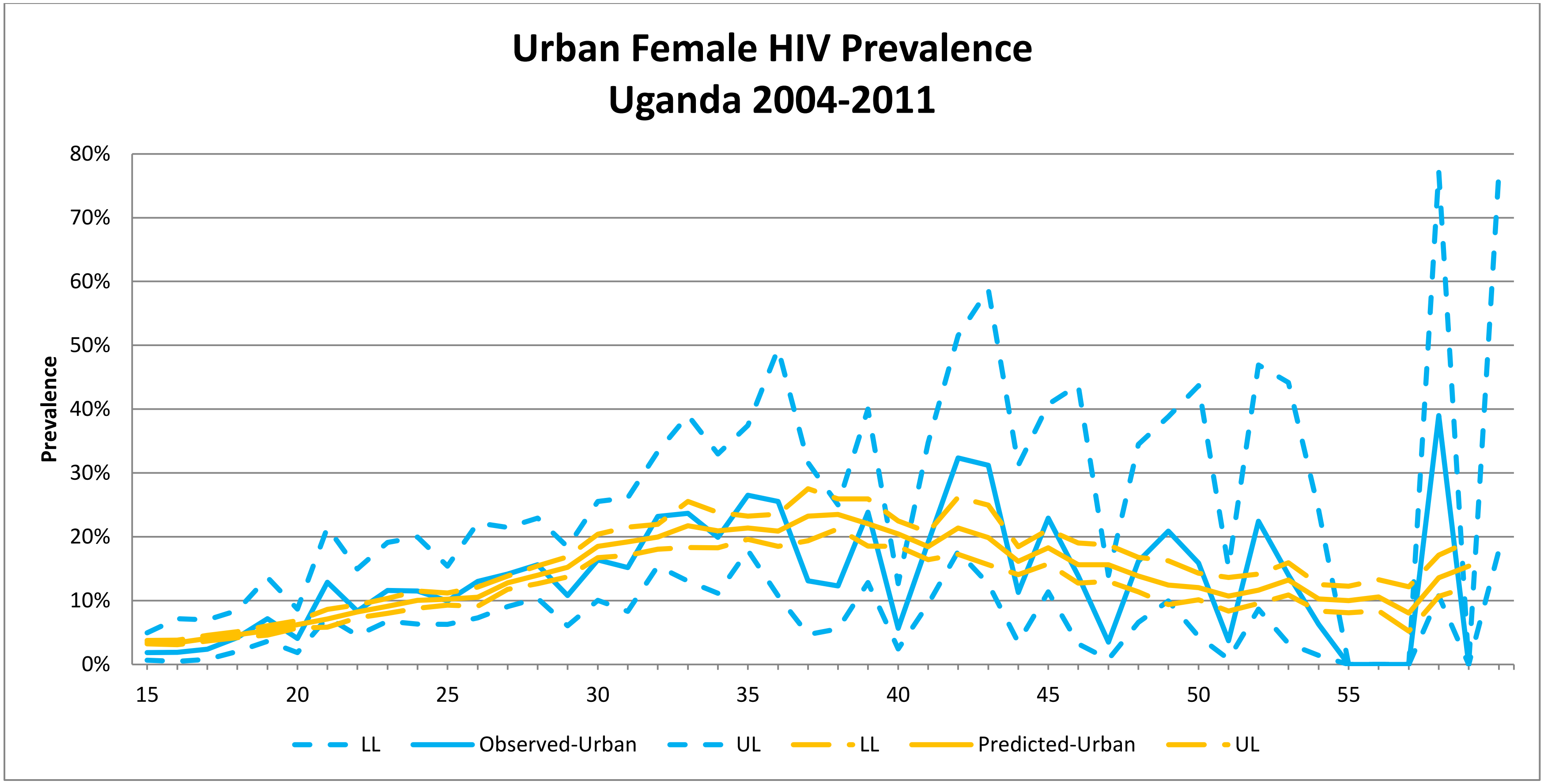
Age	Before ART (1999-2003)						After ART (2004-2009)					
	Males		Females		Total		Males		Females		Total	
	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years
15-19	0	16.7	1	52.4	1	69.1	1	18.3	0	90.2	1	108.5
20-24	2	39.3	15	147.3	17	186.6	2	50.8	9	227.7	11	278.6
25-29	10	118.9	24	267.3	34	386.2	6	130.5	18	346.4	24	476.9
30-34	17	199.1	29	223.1	46	422.2	12	248.6	18	416.3	30	665
35-39	26	153.7	23	188.7	49	342.4	9	248.2	11	333.8	20	582
40-44	15	120.8	11	78.9	26	199.7	12	213.3	9	277.3	21	490.6
45-49	16	68.3	6	57.9	22	126.2	6	144.6	9	161.9	15	306.6
50-54	7	46.6	7	39.3	14	86	4	89.1	4	95.3	8	184.4
55-59	5	16.9	2	21.2	7	38	6	50.1	4	48.3	10	98.4

HIV-negative, Deaths and person-years

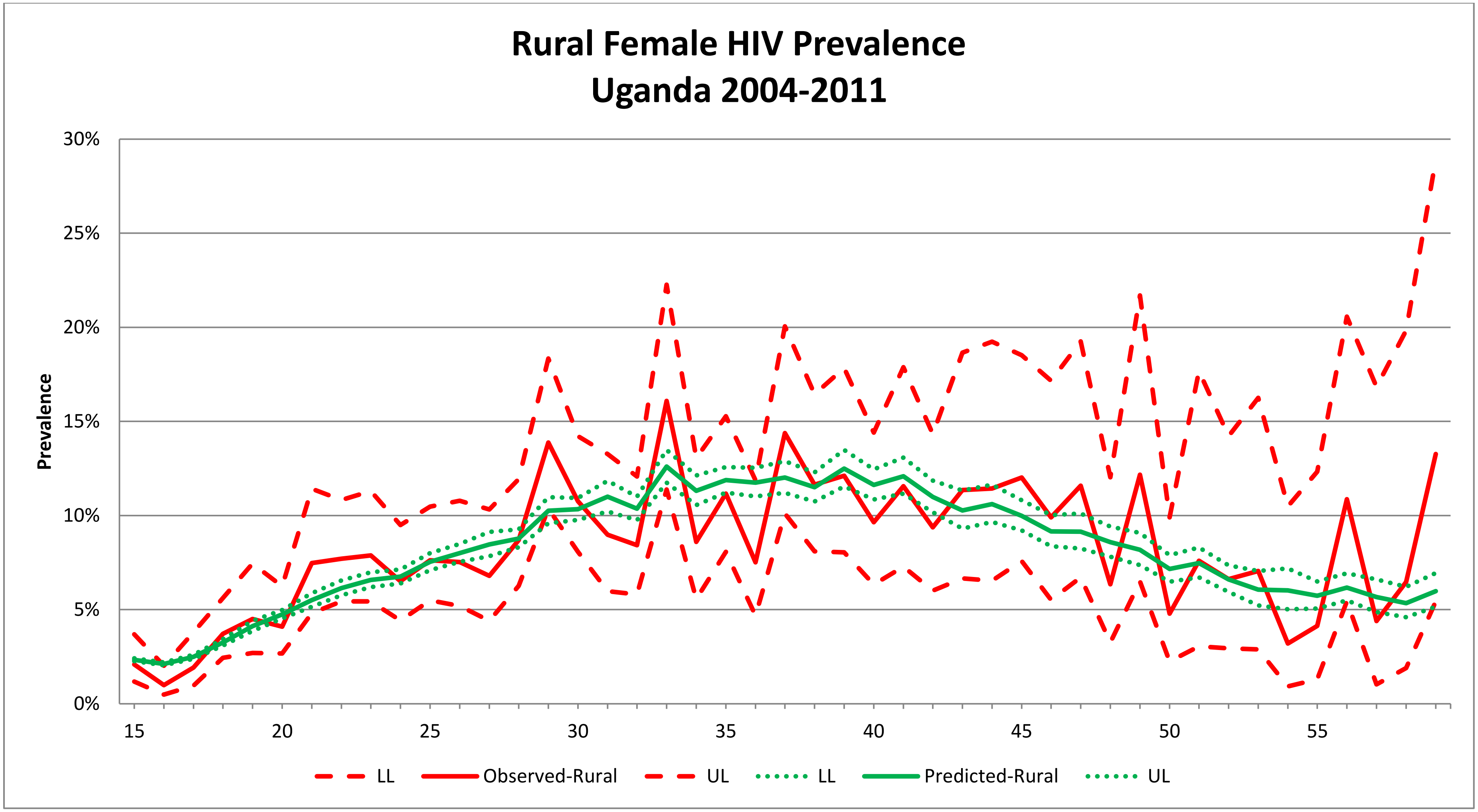
Age	Before ART (1999-2003)						After ART (2004-2009)					
	Males		Females		Total		Males		Females		Total	
	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years	Deaths	person-years
15-19	13	4393.3	7	4142.5	20	8535.7	5	6364.2	8	5748.8	13	12113.1
20-24	4	2434.5	5	2510.9	9	4945.4	9	2933.4	10	3289.0	19	6222.4
25-29	3	1740.2	6	1914.6	9	3654.9	8	2270.1	8	2786.7	16	5056.8
30-34	5	1396.3	9	1476.2	14	2872.5	4	2128.0	5	2414.5	9	4542.5
35-39	5	1175.6	5	1409.2	10	2584.9	7	1788.4	7	1949.7	14	3738.1
40-44	7	895.2	4	1133.4	11	2028.5	12	1493.0	6	1887.6	18	3380.6
45-49	5	827.7	4	867.2	9	1695	10	1161.0	6	1573.4	16	2734.3
50-54	8	589.8	3	906.7	11	1496.5	12	1073.3	6	1226.4	18	2299.7
55-59	8	504.5	7	778.5	15	1283	16	800.9	16	1200.2	32	2001.1

Table: Estimated Incidence for Males

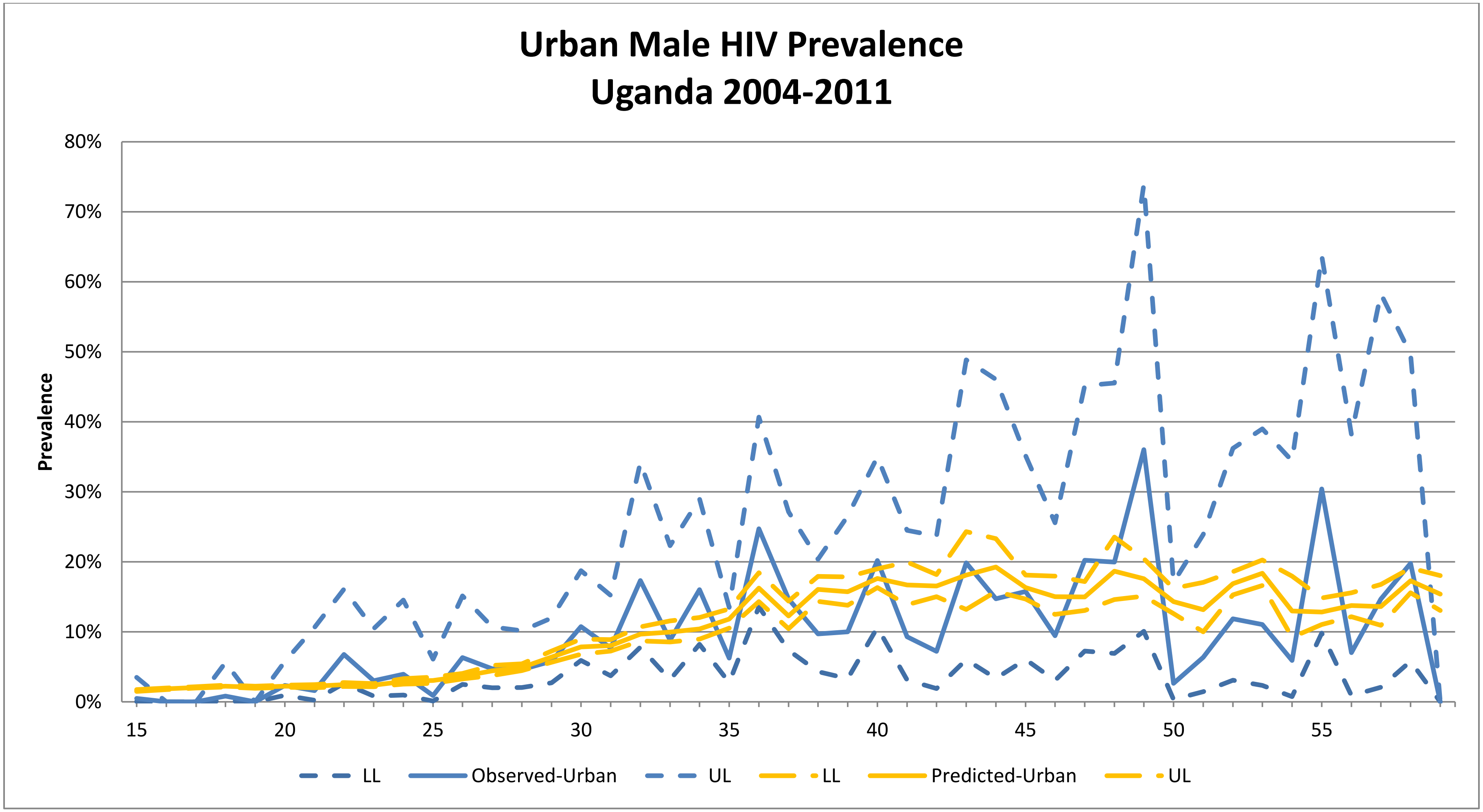
									2011								
		2004 -Males							Projection Year								
			HIV								HIV						
Age Group	2004 Age Midpoint	Population	HIV + Count	Deaths at 66% ART	Deaths at 0% ART	Annual HIV Deaths At 66%	Annual HIV Deaths At 0%	2004 Prevalence	2011 Age Midpoint	Population	Modelled HIV + Count	Modelled Prevalence	AIS Prevalence	Implied Total Incidence 66% ART	Implied Total Incidence 0% ART	Deaths Averted Due To ART	Prevalence No ART
5 to 9	7								14	1,938,710	12,757	0.66%	1.52%	12,757	12,757	0	0.66%
10 to 14	12								19	1,531,858	29,416	1.92%	2.29%	29,416	29,416	0	1.92%
15 to 19	17	1,371,936	24,106	5,280	10,221	754	1,460	1.76%	24	1,304,964	35,984	2.76%	3.10%	17,159	22,099	4,941	2.38%
20 to 24	22	1,045,299	24,382	5,701	11,552	814	1,650	2.33%	29	1,081,541	57,342	5.30%	6.09%	38,661	44,513	5,851	4.76%
25 to 29	27	878,994	35,187	8,781	18,548	1,254	2,650	4.00%	34	799,353	75,685	9.47%	10.01%	49,279	59,047	9,767	8.25%
30 to 34	32	734,388	55,598	14,737	32,209	2,105	4,601	7.57%	39	646,671	74,865	11.58%	10.82%	34,004	51,476	17,472	8.88%
35 to 39	37	525,134	58,609	16,526	37,209	2,361	5,316	11.16%	44	466,046	49,141	10.54%	10.44%	7,058	27,742	20,683	6.11%
40 to 44	42	420,405	47,901	14,317	32,973	2,045	4,710	11.39%	49	357,008	29,725	8.33%	9.20%	0	14,798	18,656	3.10%
45 to 49	47	281,787	26,132	8,311	19,475	1,187	2,782	9.27%	54	249,475	16,208	6.50%	6.75%	0	9,551	11,164	2.02%
50 to 54	52	235,043	16,979	5,617	13,396	802	1,914	7.22%	59	191,308	6,202	3.24%	5.62%	0	2,619	7,778	0.00%
55 to 59	57	159,967	8,737	1,525	4,520	218	646	5.46%	64	97,584	0	0.00%		0	0	2,995	0.00%
Total		5,652,953	297,629	80,794	180,102			5.27%		8,664,518	387,327	4.47%	5.57%	188,334	274,017	99,308	3.32%



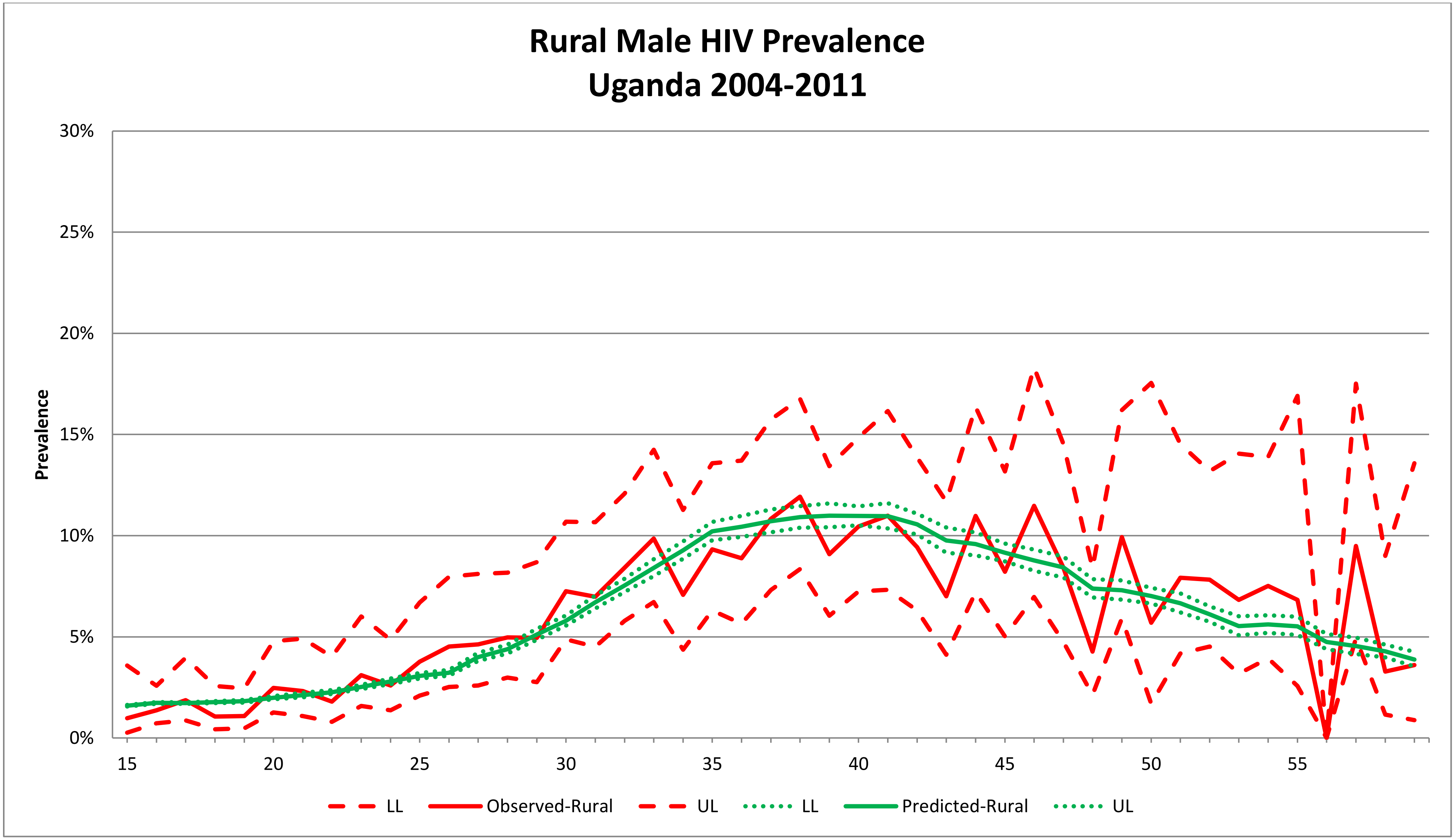
Urban Female HIV Prevalence
Uganda 2004-2011
Prevalence
80%
70%
60%
50%
40%
30%
20%
10%
0%
15
20
25
30
35
40
45
50
55
LL
Observed-Urban
UL
LL
Predicted-Urban
UL



Rural Female HIV Prevalence
Uganda 2004-2011
Prevalence
30%
25%
20%
15%
10%
5%
0%
15
20
25
30
35
40
45
50
55
LL
Observed-Rural
UL
LL
Predicted-Rural
UL



Urban Male HIV Prevalence
Uganda 2004-2011
Prevalence
80%
70%
60%
50%
40%
30%
20%
10%
0%
15
20
25
30
35
40
45
50
55
LL
Observed-Urban
UL
LL
Predicted-Urban
UL


Rural Male HIV Prevalence
Uganda 2004-2011
Prevalence
30%
25%
20%
15%
10%
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20
25
30
35
40
45
50
55
LL
Observed-Rural
UL
LL
Predicted-Rural
UL