Refusal to be tested for HIV and the likelihood of infection: a potential, but unlikely source of bias in community-based studies of HIV prevalence

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Abstract

Population-based studies involving HIV serostatus testing are regularly used to evaluate HIV prevalence estimates derived from ANC sentinel surveillance sites or to provide alternative estimates altogether. Bias in community-based estimates is, however, also plausible because of shortcomings in the sampling frame and non-response due to population mobility and/or refusal. In this paper, we investigate the association between refusal and HIV infection in a large governmental hospital in Addis Ababa, and via a comparison of ordinary regression and regression models that account for sample selection, we quantify the magnitude of the ensuing bias in HIV prevalence estimates. We find that refusal is indeed correlated with the likelihood of infection, but the resulting bias in HIV prevalence estimates –in our study population as well as in community-based studies– is likely to be negligible. The latter will depend in great part on the study protocol and informed consent procedures. We also find that consent for testing increased since the introduction of antiretroviral treatment.

Background and objectives

Most published HIV prevalence figures are based on inputs from sentinel surveillance data in antenatal clinics (ANC). Because of the importance of reasonably accurate HIV prevalence figures for policy formulation and resource allocation, the validity of these estimates have been subject to extensive scrutiny (Kigadye et al. 1993; Fontanet et al. 1998; Fylkesnes, Ndhlovu, Kasumba, Mubanga Musonda, and Sichone 1998; Zaba, Boerma, and White 2000; Glynn et al. 2001; Saphonn et al. 2002; Gregson et al. 2002; Changalucha et al. 2002; WHO/UNAIDS 2003; Crampin et al. 2003; Garcia-Calleja, Zaniewski, Ghys, Stanecki, and Walker 2004; Bignami-Van Assche, Salomon, and Murray 2005). Where ANC estimates deviate from population-based assessments of HIV prevalence, it is attributed to the representativeness of women attending antenatal clinics and/or the under-representation of remote rural areas in surveillance systems. The identification of biases have led to the development of correction schemes to improve extrapolations from ANC surveillance data (Nicoll et al. 1998; Zaba et al. 2000; Walker et al. 2003; Fylkesnes et al. 1998), but questions continue to surround the uniform applicability of adjustment procedures in a variety of settings (Crampin et al. 2003).

Expanding resources and progress in medical technology has brought HIV testing increasingly within reach of community-based study designs and that has generated new prospects of either resolving the type and magnitude of bias in sentinel surveillance or to provide a new gold standard for HIV prevalence estimates altogether (Boerma, Holt, and Black 2001; WHO/UNAIDS 2003; Boerma, Ghys, and Walker 2003; Walker, Grassly, Garnett, Stanecki, and Ghys 2004; Garcia-Calleja et al. 2005). Data from community surveys are indeed a valuable addition to antenatal clinic estimates, but they are also subject to bias due to limitations of the sampling frame (e.g. the exclusion of high risk groups such as army barracks, prisons or migrant worker hostels), and non-response because of population mobility and refusal. The association of population mobility with HIV infection has been documented extensively (Pison, Le Guenno, Lagarde, Enel, and Seck 1993; Quinn 1994; Nunn, Wagner, Kamali, Kengeya-Kayondo, and Mulder 1995; Decosas, Kane, Anarfi J.K., Sodji, and Wagner 1995; Crampin et al. 2003; Lagarde et al. 2003; Lurie et al. 2003; Lydié et al. 2004; Coffee et al. 2005). In comparison, relatively

little is known about the relationship between refusals and HIV infection in community-based studies (WHO/UNAIDS 2003; Boerma et al. 2003; Garcia-Calleja et al. 2005). A number of small-scale studies in STD and antenatal clinics most often conclude that refusals are positively associated with HIV status (Hull et al. 1988; Jones et al. 1993; Schwarcz, Bolan, Kellogg, Kohn, and Lemp 1993; Groseclose et al. 1994; Simon, Weber, Ford, Cheng, and Kerndt 1996; Paget, Zwahlen, and Eichmann 1997; Coulibaly, Msellati, Dedy, Welffens-Ekra, and Dabis 1998; Boxall and Smith 2004; Mseleku, Smith, and Guidozzi 2005), while a few suggest the opposite pattern or remain inconclusive about the nature of the relationship (Meda et al. 1999; Fabiani, Nattabi, Ayella, Ogwang, and Declich 2005; Mpairwe et al. 2005).

In the aggregate, HIV prevalence estimates from community studies are believed to underestimate true prevalence, but the few studies that exist failed to identify significant bias due to non-response (Garcia-Calleja et al. 2005; Bignami-Van Assche et al. 2005; Onyango 2005).

In this contribution we investigate refusal to be tested as one aspect of non-response and assess whether it is correlated with HIV infection in a large government hospital in Addis Ababa, Ethiopia. Via regression models that account for sample selection, we quantify the magnitude of ensuing bias in HIV prevalence estimates. An important advantage of a hospital over a random population sample is that it usually provides greater detail on the medical condition of all respondents, whether they agree to testing or not. Because health status is a good predictor of HIV status, it can be used to assess the association between refusal and HIV status. In community-based studies, most measured traits correlate only weakly with HIV status and that complicates a similar endeavor in random population samples. Medical facility-based studies, however, have the disadvantage that they are possibly not exemplary for the dynamics that affect participation in population-based surveys. The distinctive characteristics of hospital populations may operate to both contain and inflate bias in prevalence estimates due to refusal. Study participation may, for example, be motivated by the will to resolve one's medical problems and thus inhibit non-response[1]. On the other hand, and provided that

[1] Precisely for this reason, we excluded patients from the TB/HIV clinic in the hospital under surveillance from the analyses (cfr. infra).

infection positively correlates with refusal, the bias in HIV prevalence estimates may be could beinflated due to greater accuracy in respondents' self-assessed HIV status. Because true HIV status is often unobserved for respondents themselves, bias in HIV prevalence estimates is highly dependent on the correlation between true and self-assessed HIV status. In community-based studies this correlation is often low or at best moderate (WHO/UNAIDS 2003; Bignami-Van Assche, Chao, and Anglewicz 2005; Anglewicz and Kohler 2005). In a clinical setting, the symptoms that led to admission are likely to remove some of the uncertainty regarding one's HIV status, tighten the match between self-assessed and true HIV status and thus increase the potential for bias in HIV prevalence estimates due to refusal. Because of these and possibly other peculiar characteristics of hospital populations, we cannot claim that the relationships we identify are identical to those in community-based studies. We do nonetheless suspect that the direction of bias will the same in both settings, and –for reasons explained above– that the magnitude of bias due to refusal is higher in a hospital setting.

A final noteworthy feature of our study design is that ART has been introduced in the hospital under surveillance during the course of our project and that allows us to evaluate its impact on the willingness to be tested.

Setting

As is the case for many urban centers in East Africa, Addis Ababa is severely affected by the HIV/AIDS epidemic. For 2003, urban HIV prevalence is estimated at 12.6% (MOH 2004), a level which exerts great strain on the hospital infrastructure. Estimates for 2001 attribute between 46.5 and 63.4% of adult hospital deaths in Addis Ababa (age 13+) to the AIDS-related complex (Araya et al. 2004). Because of the relatively low cost of hospital services, selection bias in hospital statistics is thought to be limited. This is particularly the case for government hospitals (Reniers et al. 2005).

In July 2003, the Ethiopian government adopted a policy for the provision of ART through a fee based scheme ranging from 30 to 80US$ per month. For most Ethiopians this is still costly considering the monthly salary of an entry-level administrative

government employee is less than 50US$. By mid 2005, close to 15,000 patients were receiving antiretroviral drugs (the majority of them in the capital). A limited number of AIDS patients have been receiving antiretroviral medication since 1999 through the informal market, and usually at much higher cost.

Data collection

Surveillance of hospital admissions and outpatient visits was initiated in the Zewditu Memorial Hospital in May 2003 and lasted for nine months. Zewditu is a government medical facility in the inner city and was one of the few hospitals with a voluntary counseling and testing (VCT) centre of sufficient capacity to accommodate our study. Initially, the surveillance covered the TB-HIV clinic (TB, ambulatory patients only), the medical emergency (ER), and the internal medicine (IM), gynecology (GY) and pediatric wards (PE). For each patient, a ward nurse collected basic socio-demographic background characteristics as well as the admission and discharge diagnosis. One month after the start of the study, the surgical ward (SU) was included in the surveillance and we added educational status, birthplace and marital status as additional information to be collected for each patient. After new patients were identified, a ward nurse contacted the coordinator of the VCT unit who assigned a VCT-nurse to do pretest counseling and ask for written consent of the patient or his/her guardian[2].

Patients had the option to participate in the study without being informed of the test result (consent level A); to participate in the study and be informed of the test results (consent level B); or not to participate in the study at all (consent level C). After consent was obtained, the VCT-nurse arranged with a lab technician to take a blood sample. A Determine Rapid HIV1-2 test was carried out on the blood sample and the VCT nurse carried out post-test counseling. Capillus™ HIV-1/HIV-2 confirmatory tests were done on positive samples, and in case the outcomes of both tests were discrepant a Uni-Gold™ HIV test was done as a tie breaker. Tests were offered free of charge. As a standard practice, HIV test results were not communicated to other medical personnel with the

[2] On a couple of occasions, surveillance had to be discontinued following the reorganization of the VCT unit. Not all wards were evenly affected by the reorganization.

exception of the treating physician if s/he issued a formal request for an HIV test. In total, nine VCT nurses carried out counseling and anywhere between two and four VCT nurses covered each ward. All but one of the counselors was female.

Methods

To study whether refusals are more common among patients likely to be infected, we use the admission diagnosis as leverage because it is correlated with HIV status and also observed for patients who did not get tested. We use admission rather than discharge diagnosis for that purpose because it is less likely to be influenced by the test result. All admission diagnoses were coded using ICD-10 principles and categories and regrouped following guidelines for reporting morbidity (WHO 1993). For each entry we calculated the probability of infection and these probabilities are used as an indicator for the likelihood of infection (table 1). We use this probability rather than a set of dummies for the admission diagnosis itself for purposes of clarity. The substitution of one variable for the other does not change any of the substantive conclusions to be drawn from the analyses (not shown). The pseudo R^2 in a simple logit regression of HIV status on the likelihood of infection is 0.21, confirming that the latter is a good predictor of HIV status.

Table 1 about here

The likelihood of infection in the admission diagnosis is first used as a predictor in logistic regression models with the consent level as the outcome of interest. In these models, we verify whether its effect persists after the inclusion of controls for socio-demographic background characteristics of the respondent as well as features of the study design. In a second step we use Heckman probit models with sample selection to determine the magnitude of bias in HIV prevalence estimates due to refusal. The Heckman sample selection model is a two equation model that consists of a regression equation predicting HIV status ($y = v\beta + u_1$), and a selection equation predicting willingness to be tested ($z\gamma + u_2 > 0$). The error terms in both equations are assumed to be

normally distributed. (Heckman 1979; Winship and Mare 1992; Briggs 2004). Ordinary logistic regression estimates of HIV status are unbiased when ρ (the correlation between u_1 and u_2) is negligible; when ρ ~= 0, logistic regression estimates are biased. The Heckman selection model allows us to use information for patients who refused the HIV test (i.e. their likelihood of infection and other socio-demographic background characteristics) to improve estimates of parameters in the regression model predicting HIV status. Though Heckman estimates are sensitive to violations of assumptions regarding the presumed selection process, we are in a position to assess its validity because we can pretend that the HIV status for patients with consent level A was unknown and compare Heckman estimates with observed values.

We limit the study population in four respects. The first set of excluded cases are higher-order episodes of admission of the same individuals. Some patients are recorded twice or even three times in the surveillance because they were either admitted more than once or referred to another ward (e.g. from ER to IM). We only consider first admissions because the higher order admission diagnoses might be influenced by the test outcome at the first visit and thus introduce problems of reverse causality in our models. For similar reasons, we exclude individuals who volunteered their HIV status (mostly positive, table 2). The third category of patients that we exclude are children under two years since Rapid HIV tests cannot distinguish between individual and maternal antibodies for children below 18 months. The TB/HIV clinic constitutes another special case in our surveillance. HIV testing is standard practice in diagnosing patients and some are referred to the TB/HIV clinic precisely for that reason. The TB/HIV clinic of Zewditu hospital was also one of the pioneering –and still is one of the most important– facilities for the provision of ART in Ethiopia and this contributes to the (self-)selection of patients into the TB/HIV clinic. We therefore excluded it from the analyses. As it turns out, the TB/HIV clinic had the highest acceptance rate for being tested as well as the highest HIV prevalence rate.

Results

In total 2,719 unique patients were approached for testing. After excluding the TB/HIV clinic, and patients below two years, 1,897 cases were retained (table 2). Sixty five of them were discharged prior to being tested and 56 already knew their HIV status. Both groups are omitted from further analysis. Of all approached patients 84.7% did participate (consent A & B), and 73.9% wanted to be informed of their test result (consent level B). The percentage of outright refusals (15.3% , consent level C) is of the same order of magnitude as those observed in the DHS surveys involving serostatus testing in Mali, Kenya and Zambia (Garcia-Calleja et al. 2005). Of those in consent level A and B, 21.9% tested positive. The share of positives is markedly higher among those not wanting to be informed of their test result (consent level A, 52.08%) versus those that opted for testing and post-test counseling (consent level B, 17.45%).

Table 2 about here

Table 3 reports bivariate relationships between background characteristics and consent level. Uncontrolled for confounding factors, sex, religion and region of birth are weak predictors of consent and not shown. Among the characteristics reported in table 3, we find fewer refusals among older patients and a higher refusal rate for widows/ers, the divorced and better-educated patients. The most pronounced variability in participation rates was not by the patient's characteristics, but rather by ward and particularly by counselor. The first is possibly related to the reason for admission (and hence HIV status), but this conclusion might be confounded by the experience, approach and success of counselors in enrolling study participants. In the case of one counselor, none of the study participants wanted to be informed about their test result. The number of patients counseled by this nurse was, however, low. One of the other counselors had hardly any refusals at all. Consent for testing is also higher after the introduction of the ART program at Zewditu hospital. Particularly relevant for the analysis of bias in HIV-prevalence estimates is that the likelihood of infection in the admission diagnosis is correlated with consent level A, and to a lesser extent also with consent level C.

Table 3 about here

To explore the relationship between refusal and its predictors in a multivariate context, we use logit regression models with the consent level as the outcome of interest (table 4). In the first binary logit model (A & C versus B), the likelihood of being positive is correlated with refusal for testing and highly significant: for each 1%- point increase in the likelihood of infection, the odds for refusal increase by 1%. The analysis also confirms that counselors had variable success in obtaining consent for testing. For some of the counselors that effect is very strong. Of further interest is that refusals rate gradually declined since the introduction of ART. This assertion has to remain hypothetical as it may be due to other factors that correlate with study duration (e.g. the increasing experience of counselors). In the second model that introduces additional controls, most effects remain stable. In addition, women are 50% more likely than men to get tested and the effect of age follows a u-shaped pattern with a depression in the desire for testing in mid-adulthood. Those with higher educational status are less likely to participate in testing and that confirms the bivariate results in table 3. In terms of marital status, singles are most likely to participate in testing. The ward of admission has a marginal effect on consent; the effects of region of birth and religion are not significant and omitted from the analyses.

Table 4 about here

Breaking down the category of refusals by consent level (model 3 and 4), changes little in terms of the substantive conclusions compared to the binary logit models. The noteworthy differences are that age is a weak predictor of total refusal (C versus B) and that educational status does not have an effect in the equation predicting consent level A versus B. The parameters for marital status point in the same direction as for the binomial regression but vary in their significance level. Curious perhaps is that the effect of the likelihood of infection lost some statistical significance in the equation predicting C versus B, compared to A versus B.

To identify the magnitude of bias introduced by refusal on HIV prevalence estimates, we turn to Heckman probit models of HIV prevalence accounting for sample

selection. Heckman regression parameters are used to predict HIV prevalence and compared with estimates from standard probit models. All explanatory variables in models 2 and 4 of table 4 are used in the selection equation of the Heckman model. The Heckman regression equation predicting HIV prevalence contains age, a squared term for age, sex, the likelihood of being positive and marital status. These variables are of little substantive interest in this context and are simply chosen to maximize the predictive power of the regression equation.

In table 5 we present HIV prevalence estimates based on standard probit models and Heckman probit models under different assumptions regarding the observability of HIV status for each consent level. The bottom row reports the likelihood ratio test for the hypothesis that the error terms in the regression and selection equation are uncorrelated. Assuming that we would not have been able to observe the HIV status for patients under consent level A (column 1), the Heckman selection model estimates prevalence at 22.6% while the standard probit estimate is more than 5%-points lower. Comparing these estimates with the observed value (21.9%) illustrates that the Heckman probit model more accurately predicts HIV prevalence than a model that does not account for selection. The latter merely converges to the prevalence in the subgroup that is defined as observed (here consent level B). It is noteworthy that ρ is not significant for a Heckman model that only includes basic socio-demographic background characteristics (sex, age, marital status, and education) in the selection equation (not shown). That model also underestimates HIV prevalence. Adding counselor to the selection equation with socio-demographic background statistics renders ρ significant, but leads to an overestimate of the observed HIV prevalence. Inclusion of information on the health status of patients – an indicator that correlates well with HIV status and consent– thus improves Heckman predictions of HIV prevalence.

Table 5 about here

The last two columns compare HIV estimates for two plausible study designs: the bias in prevalence estimates will be substantial if response level is dichotomized into either refusal or full participation without a middle way (column 4). The bias is much smaller

and statistically only marginally significant if the study design explicitly allows participants to decline being informed of their test results (column 3).

Discussion

Our initial suspicion that consent is correlated with HIV status is supported by the analyses: patients who fully participate in the study and agree to post-test counseling (consent level B) are less likely to be infected than those in the other two consent groups. These results thus map better onto the idea that people get tested to corroborate negative status rather than to confirm a suspicion of infection. The latter, incidentally, has been the dominant rhetoric in VCT advocacy programs that encourage people to get tested because it enables them to initiate or maintain behaviors to prevent further transmission of HIV, and that it facilitates early access to treatment and support. The introduction of ART may change that equation in the future and the increasing consent rates since the introduction of ART do point in that direction. The absence of a control group, however, does not allow us to exclude other factors potentially responsible for this statistical association. The possibility that patients are more likely to agree to testing once a treatment becomes available is nonetheless plausible[3].

While most of the discussion focused on the relationship between the likelihood of infection and consent for testing, we must bear in mind that it was not the most important predictor of consent. The largest share of the variation in consent is absorbed by the counselors and that suggests that studies interested in minimizing non-response must take care in the selection and training of their counseling team. We have no reason to suspect bias in HIV prevalence estimates due to variability in consent attributable to the counselors.

A much more likely source of bias in prevalence estimates is the correlation of refusals with HIV status. Regression methods that account for sample selection, confirm

[3] Concern has been raised that the value of testing for HIV would only increase for sick individuals in resource poor settings because ART is primarily provided to those already symptomatic with AIDS (Glick 2005). Though still unverified, this hypothesis implies that the introduction of ART would primarily influence refusals in medical facilities and not necessarily in population-based studies.

that refusals depress HIV prevalence estimates, but that conclusion requires qualification in a few respects. One important intervening factor is the study design, and our use of three consent levels allows us to simulate that effect. Bias appears to be contained if respondents are offered the opportunity to abstain from receiving feedback on test outcomes. Simply for the sake of scientific accuracy, it is therefore advisable in biomarker collection studies to explicitly provide for that option when introducing the study objectives to the respondent. In studies where the waiting time between testing and feedback is large, this is often a de-facto option, but as technological advances in biomarker collection tend to reduce the waiting period to communicating test results, this will become a consideration of increasing importance.

In practice, most community-based studies involving serostatus testing have used testing protocols in which respondents are not informed of their test result. Those willing to be counseled are usually offered a voucher for testing in a nearby VCT center, or, are tested via a parallel VCT team that accompanies the study team (Garcia-Calleja et al. 2005; CBS, MOH and ORC Macro 2004). Refusal under such a protocol most closely matches consent level C in this study. Consent level A and C combined would be representative of refusals in studies where all respondents are approached for VCT that includes automatic feedback on HIV status. This is more typical for studies in medical facility-based settings where the primary concern is often medical intervention rather than epidemiological assessment.

The most plausible implication of these results for assessments of bias in HIV prevalence estimates in community-based studies is that they are minimal; if not negligible altogether. In this population of patients from a medical facility, the estimated prevalence accounting for selection due to outright refusal (consent level C) was only marginally different from estimates that simply ignore refusal. In addition, we have little reason to suspect that this bias will be inflated in community-based studies. For refusal to affect aggregated HIV prevalence estimates, refusal needs to be associated with the self-assessed likelihood of infection, and the self-assessed likelihood of infection, in turn, needs to correlate with true status. Particularly the latter of these correlations is likely to be higher in a medical facility population compared to a random population sample because the health status may resolve part of the information problem in self-assessments

of HIV status. A third factor affecting bias in prevalence estimates is the refusal rate itself. The difference in HIV prevalence in study participants and those that refuse testing has to be quite substantial for a refusal rate of around 15% to make a difference in aggregated HIV prevalence estimates (WHO/UNAIDS 2003). Though these conclusions are methodologically optimistic, the last word of caution is that all sources of bias in community-based estimates of HIV prevalence (i.e. limitations of the sampling frame, refusal and other forms of non-response) are likely to operate in the same direction and together they may end up being more substantial and significant than refusals by itself.

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Ethical clearance

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Table 1: admission diagnoses and likelihood of infection

	% HIV+	N	ICD-10 code
Diarrhoea and GE of presumed infectious origin	63.04	46	A09
Respiratory TB	56.60	53	A15-16
Other TB	62.50	24	A17-19
HIV	100.00	2	B2
Malaria	15.00	40	B50-54
Herpes zoster, oral candiasis, toxoplasmosis and PCP	94.59	37	B02, B37, B58-59
Other infectious and parasitic diseases	15.69	51	A01, A03, A07, A30, A35, A41, A63-64,A68, A75, A82, B45
Neoplasm's of breast, cervix, uterus and leiomyoma	14.58	48	C50, C53-55, D25-26
Other neoplasms (benign and malignant)	0.00	29	C0, C2-4, C51-52, C56-58, C6-9, D0, D22-24, D3-4
Thyroid disorders	9.72	72	E00-05
Diabetes and hypoglycemia	10.34	29	E10-E16
Diseases of the nervous system (mainly meningitis)	31.82	22	G00, G03-04, G25, G40, G54
Hypertension	31.25	48	I10-I13
Other diseases of the circulatory system	5.77	52	I05, I09, I15, I21, I31, I38, I49-51, I61, I63-64, I80, I83-I84, I86, I88, I95
Pneumonia	35.48	62	J18
Other diseases of the respiratory system	25.93	27	J11, J44-46, J86, J90, J93-94, J98
Gastritis and other diseases of the oesophagus, stomach and duodenum	15.00	60	K27, K29-31
Diseases of the appendix	6.31	111	K35, K37-38
Hernia and intestinal obstruction	5.19	77	K40, K42-43, K46, K56
Cholelithiasis and diseases of the pancreas	6.11	131	K80, K82, K85-K86
Other diseases of the digestive system	17.50	40	K04, K12, K60, K62-63, K65-66, K72-73, K75-76, K83, K91-93
Diseases of the skin and subcutaneous tissue	14.29	14	L, M
Glomerular diseases and diseases of the urinary system	13.04	23	N0-3
Diseases of male genital organs	2.50	40	N4
Inflammatory diseases of female pelvic organs and disorders of the female genital tract	19.23	26	N7-9
Complications of pregnancy and delivery	15.91	44	O
Fever of unknown origin	31.36	118	R50
Chronic illness	79.31	29	R69
Symptoms signs and abnormal clinical findings not elsewhere specified	16.90	71	R0-4, R56-58, R62
External causes and injuries	7.50	40	S, T, X
Other and unknown admission diagnoses	13.16	38	A80, B19, B56, D5-8, E15, E40-42, E55, E83, E86, E88, K36, P07, Q43, Q53, U, Z4
Total	21.88	1504	

Table 2: consent level and HIV status

	Freq.	col %	Study participants (col %)	HIV+ (row %)
1. A	192	10.12	10.81	52.08
2. B	1,313	69.21	73.93	17.45
3. C	271	14.29	15.26	-
4. known HIV status	56	2.95		84.31
5. discharged prior to testing	53	2.79		
6. expired prior to testing	12	0.63		
Total	1,897	100		

Table 3: covariates of consent

	Consent level					Consent level			
Age*	A	B	C	Total	**Counselor****	A	B	C	Total
2-19	9.94	70.47	19.59	342	1	8.06	61.29	30.65	124
20-29	11.45	74.10	14.46	498	2	4.84	91.61	3.55	310
30-39	14.25	68.70	17.05	393	3	18.97	49.14	31.9	116
40-49	9.72	77.33	12.96	247	5	27.27	72.73	0.00	44
50-59	10.79	76.98	12.23	139	6	25.00	0.00	75.00	16
60+	3.85	85.9	10.26	156	7	0.53	98.15	1.32	379
Missing	0	100	0	1	8	16.58	63.04	20.38	736
Pearson chi2(12) = 27.43 p < 0.01					9	9.80	54.90	35.29	51
					Pearson chi2(14) = 360.24, p<.01				
Education (if age >15)									
Illiterate	10.25	82.27	7.48	361	**Ward**				
1-6th grade	11.76	76.47	11.76	272	ER	13.44	76.25	10.31	640
7-12th grade	11.06	75.91	13.04	606	GY	9.45	55.22	35.32	201
>12th grade	10.32	61.90	27.78	126	IM	20.79	58.42	20.79	101
Missing	7.95	68.75	23.3	176	PE	13.07	60.8	26.13	199
Pearson chi2(8) = 48.66 p<0.01					SU	6.3	84	9.61	635
					Pearson chi2(8) = 147.44, p<.01				
Marital status (if age >15)									
Single	11.43	78.59	9.98	481	**Study month***				
Mar	9.02	76.47	14.51	765	Prior to ART	14.12	66.47	19.41	510
Div/wid	17.80	69.49	12.71	118	Since ART	9.48	76.94	13.59	1,266
Missing	10.17	67.23	22.60	177	Pearson chi2(2) = 20.71, p<.01				
Pearson chi2(6) = 26.09 , p<0.01									
Likelihood of infection (adm. diag, in %)*									
2.5 - 7.0	7.59	81.56	10.85	461					
7.1 - 16.0	9.93	70.67	19.4	433					
16.1 - 31.5	9.35	76.09	14.57	460					
31.6 – 100	16.82	66.59	16.59	422					
Pearson chi2(6) = 38.76, p<0.01									

Notes:
* In the regression models that follow, age is defined in terms of single year age groups and study month is coded 0 for the period prior to the introduction of ART and consecutive numbers for months that followed. HIV likelihood is used as the proportion HIV+ for each ICD-10 entry in table 1. The other variables are defined as shown in the table.
** Counselor #4 only worked in the TB/HIV clinic and omitted from this table and any subsequent analysis

Table 4: binary and multinomial logistic regressions predicting refusal [+]

	Binary logistic regression predicting refusal (odds ratios)		Multinomial logistic regression predicting refusal (relative risk ratios)			
	A & C versus B		A versus B	C versus B	A versus B	C versus B
	Model 1	Model 2	Model 3		Model 4	
Likelihood of infection (adm. diag)	1.01**	1.01**	1.01**	1.01**	1.01**	1.01*
Counselor (vs #1)						
Counselor 2	0.12**	0.09**	0.35**	0.06**	0.23	0.05**
Counselor 3	1.62*	2.90**	2.89**	1.29	23.28**	1.61
Counselor 5	0.86	0.38	3.89**	0.00	2.18	0.00
Counselor 7	0.03**	0.01**	0.04**	0.03**	0.01**	0.01**
Counselor 8	0.86	0.53	1.83*	0.61**	0.73	0.46
Counselor 9	1.12	0.64	1.16	1.11	0.74	0.59
Study month (vs period prior to ART)	0.85**	0.84**	0.86**	0.85**	0.85**	0.84**
Ward (vs ER)						
GY		0.96			0.46	1.67
IM		1.30			0.57	2.30*
PE		0.50			0.07**	1.14
SU		0.61*			0.37**	0.93
Male		1.56**			1.50*	1.62**
Age		1.04			1.08**	1.01
Age squared		.999*			.999**	.999
Education (vs no schooling)						
Grade 1-6		1.16			0.94	1.41
Grade 7-12		1.27			0.81	1.86**
> 12th grade		1.64*			0.75	2.76**
Marital status (vs never married)						
Married		1.38			1.22	1.53*
Sep/Div//Wid		1.70*			1.78	1.56
Number of obs	1760	1540[++]	1776		1556[++]	
LR chi2	380.4 (8)	401.89(20)	467.62 (18)		534.2(42)	
Prob > chi2	0.00	0.00	0.00		0.00	
Pseudo R2	0.19	0.23	0.18		0.23	
Log likelihood	-807	-662.84	-1099.4		-891.47	

Notes: * p < .1; ** p < .05

[+] See table 3 and the notes to that table for a definition of the explanatory variables. Other variables that were controlled for, but omitted in the final models because they lack statistical significance are birth region (1=Addis Ababa, 0=other); religion; a squared term for likelihood of infection; and interactions between the likelihood of infection and study month, the likelihood of infection and sex, sex and birth region, and sex and education.

[++] Because education and marital status were only introduced as additional variables in the second month of the surveillance, models two and four are based on fewer cases.

Table 5: comparison of HIV estimates based on standard probit models and models accounting for sample selection.

	Assumptions regarding the observed HIV status of patients at different consent levels (o=observed, u= unobserved)			
	A_u / B_o	C_u / B_o	C_u / A_o & B_o	A_u & C_u / B_o
Observed HIV%	21.9 (19.8 - 24.0)	-	-	-
E(HIV% - Probit)	16.8 (15.9 -17.8)	16.3 (15.3 -17.2)	21.0 (20.1-22.0)	17.4 (16.1-17.9)
E(HIV% -Heckman)	22.6 (21.5 - 23.6)	21.4 (20.5 - 22.4)	23.2 (22.2-24.2)	22.8 (21.9- 23.8)
LR test ρ =0	p<.01	p <.01	p =.06	p <.01

Notes: 95%- CI are reported between brackets. Using dummies for admission diagnosis rather than the likelihood of infection in these regressions hardly changes the estimated prevalence rates though one of the selection models did not converge.