

# Prevalence and Incidence of HIV Infection, Trends, and Risk Factors Among Persons Aged 15–64 Years in Kenya: Results From a Nationally Representative Study

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**Background:** Enhanced HIV surveillance using demographic, behavioral, and biologic data from national surveys can provide information to evaluate and respond to HIV epidemics efficiently.

**Methods:** From October 2012 to February 2013, we conducted a 2-stage cluster sampling survey of persons aged 18 months to 64 years in 9 geographic regions in Kenya. Participants answered questionnaires and provided blood for HIV testing. We estimated HIV prevalence, HIV incidence, described trends in HIV prevalence over the past 5 years, and identified factors associated with

HIV infection. This analysis was restricted to persons aged 15–64 years.

**Results:** HIV prevalence was 5.6% [95% confidence interval (CI): 4.9 to 6.3] in 2012, a significant decrease from 2007, when HIV prevalence, excluding the North Eastern region, was 7.2% (95% CI: 6.6 to 7.9). HIV incidence was 0.5% (95% CI: 0.2 to 0.9) in 2012. Among women, factors associated with undiagnosed HIV infection included being aged 35–39 years, divorced or separated, from urban residences and Nyanza region, self-perceiving a moderate risk of HIV infection, condom use with the last partner in the previous 12 months, and reporting 4 or more lifetime number of partners. Among men, widowhood, condom use with the last partner in the previous 12 months, and lack of circumcision were associated with undiagnosed HIV infection.

**Conclusions:** HIV prevalence has declined in Kenya since 2007. With improved access to treatment, HIV prevalence has become more challenging to interpret without data on new infections and mortality. Correlates of undiagnosed HIV infection provide important information on where to prioritize prevention interventions to reduce transmission of HIV in the broader population.

**Key Words:** HIV, prevalence, incidence, surveillance, Kenya

(*J Acquir Immune Defic Syndr* 2014;66:S13–S26)

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Kenya AIDS Indicator Survey (KAIS) 2012 was supported by the National AIDS and STI Control Programme (NASCO), Kenya National Bureau of Statistics (KNBS), National Public Health Laboratory Services (NPHLS), National AIDS Control Council (NACC), National Council for Population and Development (NCPD), Kenya Medical Research Institute (KEMRI), US Centers for Disease Control and Prevention (CDC/Kenya, CDC/Atlanta), United States Agency for International Development (USAID/Kenya), University of California, San Francisco (UCSF), Joint United Nations Team on HIV/AIDS, Japan International Cooperation Agency (JICA), Elizabeth Glaser Paediatric AIDS Foundation (EGPAF), Liverpool Voluntary Counselling and Testing (LVCT), African Medical and Research Foundation (AMREF), World Bank, and Global Fund. This publication was made possible by support from the US President's Emergency Plan for AIDS Relief through cooperative agreements (PS001805, GH000069, and PS001814) from the US Centers for Disease Control and Prevention, Division of Global HIV/AIDS. This work was also funded in part by support from the Global Fund, World Bank, and the Joint United Nations Team for HIV/AIDS.

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention and the Government of Kenya.

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## INTRODUCTION

HIV continues to be a major public health challenge in sub-Saharan Africa, where an estimated 22 million people are living with HIV.<sup>1</sup> In a population of 40 million in Kenya, 1.6 million people of all ages were living with HIV in 2012 and an estimated 98,000 of these had acquired HIV infection within the preceding year, making Kenya's HIV epidemic the fourth largest worldwide.<sup>1,2</sup> For this reason, Kenya has been regarded globally as a priority country in sub-Saharan Africa to reverse the spread of HIV in the region.

To implement effective HIV programs, nationally representative data that reflect the country's current HIV epidemiology are required. Since 2003, HIV testing has

been included in national household surveys, including the Kenya Demographic and Health Surveys (2003 and 2008-09) and the Kenya AIDS Indicator Survey (KAIS) in 2007.<sup>3-5</sup> These surveys estimated that HIV prevalence in adults ranged from 6.3% to 7.4%. Data from these surveys have provided a clearer understanding of the magnitude, distribution, and trends in HIV infection, as well as coverage of HIV treatment and prevention interventions to inform policies and programs to address the epidemic.<sup>6</sup>

We conducted a second Kenya AIDS Indicator Survey (KAIS 2012) to estimate HIV incidence and prevalence, assess trends in HIV prevalence since 2007, and identify factors associated with HIV infection to inform programmatic and policy decisions to guide the national HIV response for the next five years in Kenya.

## METHODS

KAIS 2012 was a cross-sectional household survey of persons aged 18 months to 64 years, conducted from October 2012 to February 2013. The methods of this survey are described in detail elsewhere.<sup>7</sup> The survey was designed to provide representative estimates of HIV prevalence among adults and adolescents aged 15 to 64 years at the national and regional level for the urban and rural populace. Among children aged 18 months to 14 years, the survey was powered to provide estimates of HIV prevalence at the national level only. Because of regional insecurity at the time of the survey, the North Eastern region was not sampled. For the purposes of this article, we restricted our analyses to adults and adolescents aged 15 to 64 years.

### Data Collection Procedures

Interviewers conducted face-to-face interviews with eligible participants. Interviews collected information on individual demographic and behavioral characteristics. Interview data were entered directly into tablet computers (Mirus Innovations, Mississauga, Ontario, Canada). Participants provided venous blood for HIV testing, which was performed at a central laboratory in Nairobi. If venous blood could not be collected, a finger prick was used to collect a dried capillary blood spot sample for HIV testing. Participants were informed that they would not receive the results of their laboratory tests but were offered home-based HIV testing and counseling services using the national HIV testing algorithm<sup>8</sup> if they wished to learn their HIV status in the privacy of their homes.

### Laboratory Methods

At the central laboratory, the same validated HIV testing algorithm that was used in KAIS 2007 was applied to KAIS 2012 blood samples. All specimens were initially screened with Vironostika HIV-1/2 UNIF II Plus O Enzyme Linked Immunoassay (bioMérieux, Marcy l'Étoile, France). Specimens that were reactive were then tested with the Murex HIV.1.2.O HIV Enzyme Immuno-

assay (DiaSorin, SpA, Saluggia, Italy) to confirm reactivity. Specimens with discrepant results were retested using the same algorithm. Twice discrepant results were resolved using polymerase chain reaction (Cobas Amplicor HIV-1 Monitor Test, version 1.5, Roche Molecular Diagnostics, Pleasanton, CA). HIV-positive dried blood spot specimens were tested for HIV RNA concentration using the Abbott M2000 Real-Time HIV-1 Assay (Abbott Laboratories, Abbott Park, IL) and recent HIV infection using the Limiting Antigen Avidity Enzyme Immunoassay (LAg-Avidity EIA) (Maxim Biomedical, Inc., Rockville, MD). Specimens with a normalized optical density value of 1.5 or lower on the LAg-Avidity EIA and (1) not virally suppressed (defined as HIV RNA concentration <1000 copies/mL) or (2) did not report use of antiretroviral therapy (ART) for their HIV infection were classified as indicative of recent infection. The estimated mean duration of recent infection for the assay was 130 days (95% confidence interval [CI] 118 to 142).

### Data Management

We merged interview and laboratory data to produce a final survey data set for analysis. Survey data were weighted to correct for unequal probability of selection and adjusted for interview and blood nonresponse to produce estimates that were representative of the population from which the KAIS 2012 sample was drawn. All data were analyzed using SAS version 9.3 (SAS Institute, Cary, NC).

### Data Analysis

We conducted univariate analyses and present frequencies and weighted proportions with 95% CI. Statistical significance for cross-tabulations was assessed using the Rao-Scott  $\chi^2$  test. We assessed whether there were changes in HIV prevalence between KAIS 2007 and KAIS 2012 by age, sex, residence, and geographic region. A z-test was used to test for differences in proportions between the 2 surveys, and we considered a *P* value < 0.05 to be statistically significant.

Using the PROC SURVEYLOGISTIC procedure, we conducted bivariate and multivariate analyses to identify correlates of undiagnosed HIV infection among persons who had ever had sex and report results as odds ratios (OR), adjusted odds ratios (AOR), and 95% CI. We selected undiagnosed HIV infection as our main outcome of interest to identify subpopulations that were at the highest risk of acquiring and transmitting HIV infection. Predictor variables included the following: age, education, marital status, region, residence, household wealth, risk perception, condom use, number of sexual partners, lifetime history of high-risk behavior, including injecting drugs, anal sex, and transactional sex, symptoms of sexually transmitted infection (STI), self-reported circumcision among men, and circumcision status of male partners reported by women. Variables associated with undiagnosed HIV infection at *P* value <0.2 in bivariate

analyses were tested in a multivariate model to identify factors that were independently associated with undiagnosed HIV infection. Variables that remained significantly associated with HIV infection at  $P$  value  $< 0.05$  were retained in the final model.

To estimate the number of adults and adolescents aged 15–64 years living with HIV and number with recently acquired HIV infection, we applied non-normalized survey weights to our HIV outcome variable. Non-normalized weights were based on the 2012 projected population data derived from the 2009 Kenya Population and Housing Census.<sup>2</sup> Annualized HIV incidence was calculated using the World Health Organization's recommended formula for estimating assay-based HIV incidence.<sup>9</sup> The annual HIV transmission rate per 100 persons living with HIV was calculated by dividing the estimated HIV incidence by the estimated HIV prevalence and multiplying this value by 100.<sup>10</sup>

This study was approved by the Kenya Medical Research Institute Ethical Review Committee, the Institutional Review Board of the US Centers for Disease Control and Prevention, and the Committee on Human Research of the University of California, San Francisco.

## RESULTS

### Eligibility and Characteristics of Study Population

Of the 16,383 persons eligible for the survey, 13,720 (83.7%) consented to an interview. Among the 13,720 individuals in the interview sample, 11,626 (84.7%) provided a blood sample, representing the serologic sample from which HIV prevalence was estimated. Compared with individuals in the interview sample, significantly higher proportions of individuals in the serologic sample were from rural residences (64.1% compared with 56.4%,  $P = 0.003$ ), from North Rift region (14.2% compared with 1.0%,  $P < 0.001$ ), had ever been widowed (6.1% compared with 5.5%,  $P = 0.002$ ), and were women who had been pregnant in the past (78.8% compared with 73.5%,  $P < 0.001$ ), respectively (Table 1). In addition, compared with persons in the interview sample, significantly higher proportions of persons in the serologic sample reported being sexually active in the past 12 months (72.3% compared with 68.1%,  $P = 0.003$ ), perceived that their risk of HIV infection was great (5.0% compared with 3.3%,  $P = 0.005$ ), had received their last HIV test more than 12 months preceding the survey (45.1% compared with 38.1%,  $P < 0.001$ ), and self-reported HIV-positive status based on their HIV testing history (4.1% compared with 2.1%,  $P < 0.001$ ), respectively.

Among the 11,626 participants in the serologic sample, 51.3% were women. The median age was 33 years (interquartile range, 25–43). Over half (52.7%) had completed secondary school education or higher. The majority (64.1%) resided in rural areas; 14.7% were from Nyanza, 14.3% from Eastern South, 14.2% from North Rift, 9.8% from Nairobi, and 1.1% from Eastern North

regions. Over half (57.5%) were currently in married or cohabiting relationships.

Most (87.4%) reported having ever had sexual intercourse, and 72.3% reported sexual intercourse in the past 12 months. Among these, 11.5% reported 2 or more partners in the past 12 months. Eighty-five percent of participants reported no to low self-perceived risk of HIV infection. Anal sex was reported by 1.9%. Receiving money, gifts, and favors in exchange for sex was reported by 3.8%. In total, 17.8% of men reported ever giving money, gifts, or favors in exchange for sex. Symptoms of STI in the past 12 months, including genital sores and/or vaginal (women only), penile (men only), or anal discharge were reported by 5.8% (2.7% of men and 8.7% of women). Among women, 78.8% had ever been pregnant, and 6.2% were currently pregnant at the time of the survey. Ninety-one percent of men were circumcised, and 70.1% of women reported that their current male partner was circumcised.

### HIV Prevalence and Incidence

HIV prevalence was 5.6% (95% CI: 4.9 to 6.3), and HIV incidence was 0.5% (95% CI: 0.2 to 0.9), corresponding to an annual HIV transmission rate of 8.9 per 100 HIV-infected persons. Regional differences in HIV prevalence were observed with the highest HIV prevalence noted in Nyanza region (15.1%, 95% CI: 11.4 to 18.8) and lowest in Eastern North region (2.1%, 95% CI: 1.0 to 3.2) (Table 2). Women had significantly higher HIV prevalence than men (6.9% vs. 4.4%;  $P < 0.0001$ ). HIV prevalence increased with age, peaking at age 35–39 years among women (12.3%, 95% CI: 9.4 to 15.2) and age 45–54 years among men (7.2%, 95% CI: 4.9 to 9.6) (data not shown). HIV prevalence was highest among persons who had been widowed (20.0%, 95% CI: 16.2 to 23.7), separated or divorced (10.9%, 95% CI: 8.4 to 13.4), or were married or cohabiting in a polygamous relationship (9.7%, 95% CI: 6.4 to 13.1).

### Trends in HIV Prevalence, 2007–2012

HIV prevalence declined significantly from 7.2% (excluding North Eastern region) in 2007 to 5.6% in 2012 ( $P = 0.002$ ; Fig. 1). Significant declines were observed for both men (5.5% in 2007 to 4.4% in 2012;  $P = 0.0310$ ) and women (8.5% in 2007; 6.9% in 2012;  $P = 0.006$ ) (data not shown). We observed differential changes in HIV prevalence across age groups. In 2007, HIV prevalence peaked among persons aged 30–34 years (11.9%; 95% CI: 10.0 to 13.5), while in 2012, HIV prevalence peaked among persons aged 45–49 years (9.8%, 95% CI: 7.1 to 12.5). HIV prevalence declined significantly for persons who were aged 15–34 years in 2007 and 2012 ( $P \leq 0.010$ ) but remained unchanged among persons aged 35 years and older in the same time period.

In Table 3, we describe trends in HIV prevalence between 2007 and 2012 for select age groups by sex, geographic location, and residence. Among persons aged 15–24 years, we observed significant declines in HIV

**TABLE 1.** Select Demographic, Behavioral, and Biologic Characteristics of Persons Aged 15–64 Years by Sample Type Kenya AIDS Indicator Survey 2012

	Interview Sample: Interviewed and Did Not Provide a Blood Sample (N = 2094)		Serologic Sample: Interviewed and Provided a Blood Sample (N = 11,626)		P*
	Total		Total		
	Unweighted, N†	Weighted % (95% CI)	Unweighted, N†	Weighted % (95% CI)	
Sociodemographic characteristics					
Sex					0.208
Men	930	50.3 (48.0 to 52.6)	4836	48.7 (47.6 to 49.8)	
Women	1164	49.7 (47.4 to 52.0)	6790	51.3 (50.2 to 52.4)	
Age group, yrs					0.007
15–19	381	18.3 (16.1 to 20.5)	1912	16.5 (15.5 to 17.5)	
20–24	342	15.9 (14.3 to 17.6)	1907	16.3 (15.4 to 17.3)	
25–29	355	17.8 (15.9 to 19.7)	1786	15.2 (14.3 to 16.1)	
30–34	273	13.5 (11.8 to 15.2)	1424	12.1 (11.4 to 12.9)	
35–39	194	9.2 (7.8 to 10.7)	1222	10.6 (10.0 to 11.3)	
40–44	177	8.1 (6.7 to 9.5)	985	8.6 (8.0 to 9.2)	
45–49	134	6.1 (4.8 to 7.4)	715	6.3 (5.8 to 6.8)	
50–54	110	5.1 (4.0 to 6.3)	735	6.3 (5.8 to 6.8)	
55–59	74	3.4 (2.4 to 4.3)	523	4.5 (4.0 to 5.0)	
60–64	54	2.6 (1.8 to 3.5)	417	3.6 (3.1 to 4.0)	
Highest educational attainment					0.101
No primary education	240	8.6 (6.5 to 10.8)	1338	7.0 (5.8 to 8.3)	
Incomplete primary education	172	7.1 (5.6 to 8.6)	988	7.6 (6.7 to 8.6)	
Completed primary education	622	30.4 (27.6 to 33.2)	3694	32.6 (31.2 to 34.1)	
Completed secondary education or higher	1060	53.9 (50.6 to 57.2)	5606	52.7 (50.9 to 54.4)	
Region					<0.001
Nairobi	431	17.5 (14.6 to 20.4)	1314	9.8 (8.7 to 10.9)	
Central	157	9.3 (5.9 to 12.6)	1423	13.9 (12.2 to 15.6)	
Coast	203	10.2 (7.4 to 13.1)	1462	9.1 (7.7 to 10.5)	
Eastern North	224	14.3 (11.0 to 17.6)	1061	1.1 (0.9 to 1.4)	
Eastern South	193	12.3 (8.8 to 15.8)	1260	14.3 (12.6 to 16.0)	
North Rift	159	1.0 (0.7 to 1.3)	1031	14.2 (11.4 to 17.0)	
Nyanza	204	14.3 (10.5 to 18.1)	1631	14.7 (12.8 to 16.7)	
South Rift	273	11.1 (8.6 to 13.6)	1036	12.0 (9.9 to 14.0)	
Western	250	10.1 (6.4 to 13.8)	1408	10.8 (9.2 to 12.4)	
Residence					0.003
Rural	1137	56.4 (51.7 to 61.1)	7501	64.1 (61.5 to 66.7)	
Urban	957	43.6 (38.9 to 48.3)	4125	35.9 (33.3 to 38.5)	
Wealth index					
Poorest	416	18.2 (14.8 to 21.7)	2434	19.4 (16.7 to 22.1)	
Second	360	17.2 (14.7 to 19.8)	2497	21.5 (19.5 to 23.4)	
Third	357	18.4 (15.3 to 21.5)	2318	20.1 (18.2 to 22.0)	
Fourth	403	19.4 (16.2 to 22.7)	2177	19.3 (17.1 to 21.4)	
Richest	558	26.7 (22.2 to 31.1)	2200	19.8 (17.1 to 22.5)	
Marital status					0.002
Never married/never cohabited	699	33.8 (31.2 to 36.5)	3291	29.4 (28.1 to 30.8)	
Ever widowed	137	5.3 (4.3 to 6.3)	894	7.0 (6.4 to 7.6)	
Separated or divorced	110	5.5 (4.3 to 6.7)	739	6.1 (5.5 to 6.7)	
Currently married or cohabiting—polygamous	113	5.0 (3.7 to 6.3)	753	5.8 (5.0 to 6.5)	
Currently married or cohabiting—monogamous	1029	50.3 (47.6 to 53.1)	5945	51.7 (50.3 to 53.1)	
Behavioral indicators					
Ever had sexual intercourse					0.029
No	320	14.8 (12.8 to 16.8)	1507	12.6 (11.7 to 13.6)	
Yes	1766	85.2 (83.2 to 87.2)	10,097	87.4 (86.4 to 88.3)	
Lifetime number of partners					<0.001

**TABLE 1.** (Continued) Select Demographic, Behavioral, and Biologic Characteristics of Persons Aged 15–64 Years by Sample Type Kenya AIDS Indicator Survey 2012

	Interview Sample: Interviewed and Did Not Provide a Blood Sample (N = 2094)		Serologic Sample: Interviewed and Provided a Blood Sample (N = 11,626)		P*
	Total		Total		
	Unweighted, N†	Weighted % (95% CI)	Unweighted, N†	Weighted % (95% CI)	
1	611	31.9 (29.3 to 34.5)	3263	28.9 (27.5 to 30.3)	
2–3	597	33.6 (31.1 to 36.1)	3575	35.3 (34.1 to 36.6)	
4+	389	24.4 (21.9 to 26.9)	2550	29.2 (27.8 to 30.6)	
Do not know	159	10.1 (8.0 to 12.2)	620	6.6 (5.6 to 7.5)	
Sexually active in the past 12 mo					0.003
No	687	31.9 (29.2 to 34.6)	3420	27.7 (26.4 to 29.0)	
Yes	1407	68.1 (65.4 to 70.8)	8206	72.3 (71.0 to 73.6)	
No. partners in the past 12 mo					0.657
1	1241	89.0 (86.9 to 91.1)	7290	88.5 (87.6 to 89.4)	
2+	138	11.0 (8.9 to 13.1)	830	11.5 (10.6 to 12.4)	
Used a condom with last partner in the past 12 mo‡					0.297
No	1146	82.3 (79.7 to 84.9)	6886	83.7 (82.6 to 84.8)	
Yes	240	17.7 (15.1 to 20.3)	1256	16.3 (15.2 to 17.4)	
HIV risk perception					0.005
No risk	866	46.4 (43.5 to 49.3)	4213	42.1 (40.1 to 44.0)	
Low risk	711	40.5 (37.3 to 43.8)	4240	43.0 (40.9 to 45.1)	
Moderate risk	169	9.8 (8.2 to 11.4)	1023	10.0 (9.1 to 10.8)	
Great risk	57	3.3 (2.3 to 4.2)	457	5.0 (4.4 to 5.5)	
Most-at-risk behaviors					
Ever injected drugs for pleasure					0.204
No	2089	99.7 (99.4 to 100)	11,595	99.9 (99.9 to 100)	
Yes	5	0.3 (0.0 to 0.6)	9	0.1 (0.0 to 0.1)	
Ever had anal sex					0.262
No	1744	98.6 (97.9 to 99.2)	9897	98.1 (97.7 to 98.5)	
Yes	22	1.4 (0.8 to 2.1)	189	1.9 (1.5 to 2.3)	
Ever received money, gifts, or goods in exchange for sex					0.945
No	1699	96.2 (95.2 to 97.2)	9613	96.2 (95.7 to 96.7)	
Yes	67	3.8 (2.8 to 4.8)	381	3.8 (3.3 to 4.3)	
Ever gave money, gifts, or goods in exchange for sex (men only)					0.448
No	664	83.8 (80.3 to 87.2)	3385	82.2 (80.2 to 84.3)	
Yes	121	16.2 (12.8 to 19.7)	684	17.8 (15.7 to 19.8)	
Biologic indicators					
Reported STI symptoms in the past 12 mo					0.001
No	1703	96.4 (95.4 to 97.4)	9484	94.2 (93.6 to 94.8)	
Yes	63	3.6 (2.6 to 4.6)	613	5.8 (5.2 to 6.4)	
Ever been tested for HIV					0.895
No	587	28.5 (26.2 to 30.8)	3121	28.3 (26.7 to 30.0)	
Yes	1484	71.5 (69.2 to 73.8)	8463	71.7 (70.0 to 73.3)	
Been tested for HIV in the past 12 mo§					<0.001
No	562	38.1 (35.0 to 41.2)	3778	45.1 (43.5 to 46.6)	
Yes	905	61.9 (58.8 to 65.0)	4625	54.9 (53.4 to 56.5)	
Self-reported HIV status‡					<0.001
HIV-positive	29	2.1 (1.3 to 2.9)	328	4.1 (3.4 to 4.8)	
HIV-negative	1383	97.9 (97.1 to 98.7)	7916	95.9 (95.2 to 96.6)	
Ever pregnant (women only)					<0.001
No	299	26.5 (23.2 to 29.9)	1338	21.2 (19.7 to 22.6)	
Yes	799	73.5 (70.1 to 76.8)	4939	78.8 (77.4 to 80.3)	

(continued on next page)

**TABLE 1. (Continued)** Select Demographic, Behavioral, and Biologic Characteristics of Persons Aged 15–64 Years by Sample Type Kenya AIDS Indicator Survey 2012

	Interview Sample: Interviewed and Did Not Provide a Blood Sample (N = 2094)		Serologic Sample: Interviewed and Provided a Blood Sample (N = 11,626)		P*
	Total		Total		
	Unweighted, N†	Weighted % (95% CI)	Unweighted, N†	Weighted % (95% CI)	
Currently pregnant (women only)					0.685
No	962	93.4 (91.7 to 95.1)	5501	93.8 (93.0 to 94.6)	
Yes	74	6.6 (4.9 to 8.3)	365	6.2 (5.4 to 7.0)	
Circumcised (men only)					0.687
No	96	9.6 (7.1 to 12.1)	441	9.1 (7.5 to 10.7)	
Yes	834	90.4 (87.9 to 92.9)	4395	90.9 (89.3 to 92.5)	
Male partner circumcised (women only)					0.027
No	406	34.0 (30.4 to 37.6)	2008	29.9 (27.8 to 32.1)	
Yes	758	66.0 (62.4 to 69.6)	4782	70.1 (67.9 to 72.2)	

\*P value based on Rao–Scott  $\chi^2$  test. Statistically significant differences between are represented by  $P < 0.05$ .

†Because of missing responses, totals vary between variables.

‡Among persons who reported being sexually active in the past 12 months.

§Among persons who had ever been tested for HIV.

NA, not applicable.

prevalence for women (5.6% in 2007 to 3.0% in 2012;  $P < 0.001$ ) but not for men (1.0% in 2007 to 1.1% in 2012;  $P = 0.864$ ). For women aged 15–24 years, significant declines in HIV prevalence were observed among those residing in Nairobi (5.8% in 2007 to 1.8% in 2012;  $P = 0.038$ ), Coast (5.7% in 2007 to 2.0% in 2012;  $P = 0.026$ ), and Eastern (4.3%, in 2007 to 0.6% in 2012;  $P = 0.001$ ) regions and those residing in rural areas (5.7% in 2007 to 2.8% in 2012;  $P < 0.001$ ). Among men aged 15–24 years, significant declines in HIV prevalence were observed among those residing in Coast region (4.5% to 0.5%;  $P = 0.041$ ) and rural areas (1.4% to 0.4%;  $P = 0.012$ ).

Among persons aged 25–34 years, we observed declining HIV prevalence among men (8.1% in 2007 to 5.4% in 2012;  $P = 0.013$ ) and women (12.0% in 2007 to 7.3% in 2012;  $P < 0.001$ ). Among women aged 25–34 years, significant declines were observed among those residing in Nairobi (14.0% to 6.6%;  $P = 0.002$ ), Coast (11.6% to 4.1%;  $P = 0.005$ ), and Rift Valley (11.2% to 4.0%;  $P = 0.003$ ) regions and those residing in both rural (11.4% to 6.3%;  $P < 0.001$ ) and urban (13.5% to 8.7%;  $P = 0.036$ ) areas in 2007 and 2012, respectively. Among men aged 25–34 years, significant declines were observed in Coast region (7.1% in 2007 to 0.6% in 2012;  $P = 0.002$ ) and among persons residing in rural areas (8.0% in 2007 to 4.9% in 2012;  $P = 0.033$ ). Among persons aged 35 years and older, no changes in HIV prevalence were observed across sex and urban/rural residences between 2007 and 2012. HIV prevalence, however, increased significantly among women residing in Central region, from 3.1% in 2007 to 8.4% 2012 ( $P = 0.001$ ).

### Factors Associated With Undiagnosed HIV Infection

Of the 10,097 persons who had ever had sex, 6.3% (95% CI: 5.3 to 7.1) were HIV infected (Table 2); 52.2%

(95% CI: 46.5 to 57.8) of these had undiagnosed HIV infection (data not shown). We compared individuals with undiagnosed HIV infection with those who were HIV uninfected to assess factors associated with undiagnosed HIV infection. Among men, factors that were independently associated with increased odds of undiagnosed HIV infection were widowhood (AOR: 8.1, 95% CI: 1.9 to 34.6,  $P = 0.005$ ) and using a condom with the last sexual partner in the past year (AOR: 3.3, 95% CI: 1.8 to 6.2,  $P < 0.001$ ) (Table 4). In contrast, men who were circumcised had significantly lower odds of undiagnosed HIV infection (AOR: 0.3, 95% CI: 0.1 to 0.5,  $P < 0.001$ ). Among women, higher odds of undiagnosed HIV infection were associated with being aged 34–39 years (AOR: 4.5, 95% CI: 1.1 to 18.3,  $P = 0.037$ ), separated or divorced (AOR: 2.3, 95% CI: 1.1 to 5.0,  $P = 0.033$ ), residence in Nyanza region (AOR: 2.9, 95% CI: 1.4 to 6.0,  $P = 0.004$ ), living in urban areas (AOR: 1.8, 95% CI: 1.1 to 2.7,  $P = 0.012$ ), having a moderate self-perceived risk of HIV infection (AOR: 2.1, 95% CI: 1.3 to 3.5,  $P = 0.002$ ), using a condom with the last sexual partner in the past year (AOR: 2.3, 95% CI: 1.2 to 4.2,  $P < 0.009$ ), and reporting  $\geq 4$  lifetime number of sexual partners (AOR: 1.9, 95% CI: 1.1 to 3.4,  $P = 0.026$ ).

### DISCUSSION

This population-based survey provides an update on the status of the HIV epidemic in Kenya. HIV prevalence was 5.6% and HIV incidence was 0.5% among persons aged 15–64 years. This represents approximately 1,192,000 million (95% CI: 1,037,000 to 1,347,000) adults and adolescents living with HIV in 2012, 106,000 (95% CI 32,000 to 180,000) of whom had recently acquired their HIV infection within the preceding year. These results broadly corroborate the 2012 estimates

**TABLE 2.** Weighted HIV Prevalence by Demographic, Behavioral, and Biological Indicators, Persons Aged 15–64 Years, Kenya AIDS Indicator Survey 2012

Select Characteristics	Unweighted, N	HIV-positive (Unweighted, n*)	Weighted HIV Prevalence % (95% CI)
Total	11,626	648	5.6 (4.9 to 6.3)
Sex			
Men	4836	193	4.4 (3.6 to 5.2)
Women	6790	455	6.9 (6.0 to 7.7)
Age group, yrs			
15–19	1912	17	1.0 (0.5 to 1.6)
20–24	1907	58	3.1 (2.2 to 4.0)
25–29	1786	112	6.3 (4.8 to 7.7)
30–34	1424	97	6.6 (5.2 to 8.0)
35–39	1222	108	8.7 (6.7 to 10.7)
40–44	985	90	9.3 (7.1 to 11.6)
45–49	715	66	9.8 (7.1 to 12.5)
50–54	735	60	8.4 (6.3 to 10.5)
55–59	523	24	4.4 (2.4 to 6.4)
60–64	417	16	4.0 (2.0 to 6.1)
Highest educational attainment			
No primary education	1338	44	3.6 (2.4 to 4.8)
Incomplete primary education	988	46	5.0 (3.2 to 6.7)
Completed primary education	3694	223	6.0 (4.9 to 7.0)
Completed secondary education or higher	5606	335	5.8 (4.9 to 6.7)
Region			
Nairobi	1314	67	4.9 (3.7 to 6.1)
Central	1423	60	3.8 (2.7 to 4.9)
Coast	1462	66	4.3 (3.0 to 5.6)
Eastern North	1061	29	2.1 (1.0 to 3.2)
Eastern South	1260	46	3.9 (2.4 to 5.3)
Nyanza	1631	242	15.1 (11.4 to 18.8)
North Rift	1036	37	3.1 (2.0 to 4.2)
South Rift	1031	42	4.3 (2.7 to 5.8)
Western	1408	59	4.7 (3.0 to 6.5)
Residence			
Rural	7501	373	5.1 (4.3 to 5.9)
Urban	4125	275	6.5 (5.4 to 7.7)
Wealth index			
Poorest	2434	97	4.2 (2.9 to 5.4)
Second	2497	153	6.5 (4.9 to 8.1)
Third	2318	137	6.0 (4.6 to 7.4)
Fourth	2177	159	6.8 (5.3 to 8.3)
Richest	2200	102	4.6 (3.7 to 5.6)
Marital status			
Never married/never cohabited	3291	58	1.8 (1.3 to 2.3)
Ever widowed	894	165	20.0 (16.2 to 23.7)
Separated or divorced	739	83	10.9 (8.4 to 13.4)
Currently married or cohabiting—polygamous	753	68	9.7 (6.4 to 13.1)
Currently married or cohabiting—monogamous	5945	274	4.8 (4.0 to 5.7)
Behavioral indicators			
Ever had sexual intercourse			
No	1507	10	0.9 (0.3 to 1.6)
Yes	10,097	636	6.3 (5.5 to 7.1)
Lifetime number of partners			
1	3263	128	3.8 (3.0 to 4.6)
2–3	3575	236	6.1 (5.1 to 7.1)

(continued on next page)

**TABLE 2.** (Continued) Weighted HIV Prevalence by Demographic, Behavioral, and Biological Indicators, Persons Aged 15–64 Years, Kenya AIDS Indicator Survey 2012

Select Characteristics	Unweighted, N	HIV-positive (Unweighted, n*)	Weighted HIV Prevalence % (95% CI)
4+	2550	208	8.2 (6.8 to 9.6)
Do not know	620	62	10.6 (7.6 to 13.7)
Sexually active in the past 12 mo			
No	3420	175	5.2 (4.3 to 6.0)
Yes	8206	473	5.8 (5.0 to 6.7)
No. partners in the past 12 mo†			
1	7290	403	5.6 (4.7 to 6.5)
2+	830	65	7.4 (5.3 to 9.4)
Used a condom with last partner in the past 12 mo†			
No	6886	291	4.2 (3.5 to 4.9)
Yes	1256	179	14.0 (11.1 to 17.0)
HIV risk perception			
No risk	4213	89	2.1 (1.6 to 2.7)
Low risk	4240	151	3.5 (2.8 to 4.2)
Moderate risk	1023	59	5.4 (3.9 to 6.9)
Great risk	457	41	9.2 (6.2 to 12.2)
Most-at-risk behaviors			
Ever injected drugs for pleasure			
No	11,617	647	5.6 (4.9 to 6.3)
Yes	9	1	‡
Ever had anal sex			
No	9908	621	6.3 (5.5 to 7.0)
Yes	189	15	8.9 (4.6 to 13.1)
Ever received money, gifts, or goods in exchange for sex			
No	9716	600	6.2 (5.4 to 7.0)
Yes	381	36	9.5 (6.1 to 12.8)
Ever gave money, gifts, or goods in exchange for sex (men only)			
No	3415	141	4.5 (3.5 to 5.5)
Yes	684	48	6.9 (4.7 to 9.1)
Biologic indicators			
Reported STI symptoms in the past 12 mo			
No	9484	562	5.9 (5.2 to 6.7)
Yes	613	74	12.5 (9.0 to 16.0)
Ever been tested for HIV			
No	3121	72	2.5 (1.9 to 3.2)
Yes	8463	574	6.9 (6.0 to 7.7)
Circumcised (men only)			
No	441	70	16.5 (12.7 to 20.2)
Yes	4395	123	3.1 (2.5 to 3.8)
Male partner circumcised (women only)			
No	2008	210	10.9 (9.1 to 12.7)
Yes	4782	245	5.2 (4.4 to 6.0)

\*Because of missing responses, totals may vary between variables.

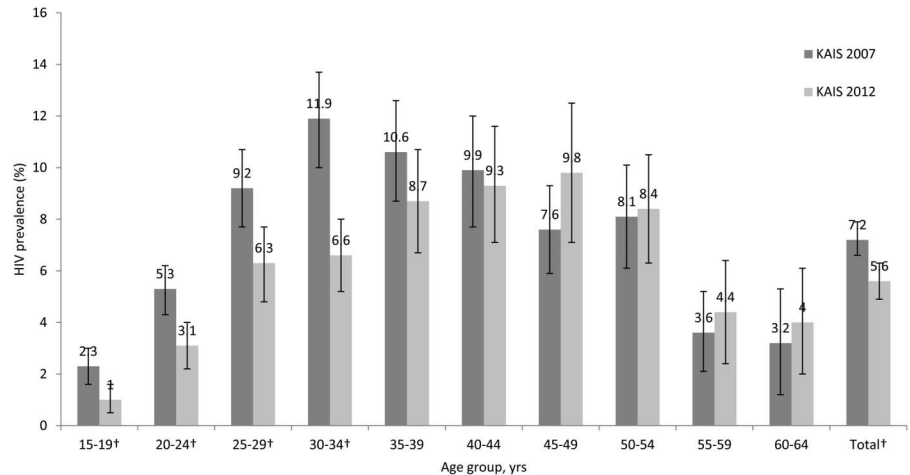
†Among persons who reported being sexually active in the past 12 months.

‡Estimate suppressed due to small sample size (N&lt;25 observations).

published by the Joint United Nations Programme on HIV/AIDS in 2013, which reported that the number of Kenyan adults and adolescents aged  $\geq 15$  years living with HIV/AIDS in 2012 was 1,400,000 (lower estimate: 1,400,000; upper estimate: 1,500,000), and the number of new infec-

tions was 85,000 (lower estimate: 80,000; upper estimate: 96,000).<sup>1</sup> Based on our results, the annual HIV transmission rate was 8.9 per 100 persons living with HIV in 2012. In other words, 9% of all persons living with HIV in 2012 were transmitting to HIV-negative persons. In comparison,





**FIGURE 1.** Trends in HIV prevalence among persons aged 15–64 years by age group, KAIS 2007\* and KAIS 2012.

\*The North Eastern region was excluded from the KAIS 2007 sample for comparability to KAIS 2012. †P ≤ 0.01.

the annual transmission rate in the United States, where 16% of the HIV-infected population remains undiagnosed, was 4.1 per 100 HIV-infected persons in 2010.<sup>10</sup>

Our data confirm a significant decline in HIV prevalence from 7.2% (excluding North Eastern region) in 2007 to 5.6% in 2012, with similar declines noted across male and female sex. Based on mathematically modeled HIV incidence in 2007, our results also suggest that HIV incidence may have declined from 0.7% in 2007 to 0.5% in 2012, coinciding with similar declines in new HIV infections reported by at least 26 countries in Africa, Asia, and the Caribbean between 2001 and 2012.<sup>1,11</sup> Declining incidence is also supported by the observation that HIV prevalence reduced significantly among younger persons aged 15–34 years between 2007 and 2012 but remained unchanged among older persons aged 35 years and above.

Among persons aged 15–34 years, we observed differential trends in HIV prevalence across geographic regions and sex, providing important epidemiologic evidence on sub-populations where substantial reductions in HIV infection may be occurring. Among women, declining prevalence was observed for women aged 15–34 years in Nairobi and Coast regions, women aged 15–24 years in Eastern region, and women aged 25–34 years in Rift Valley region. Among men, declining prevalence was observed among men aged 15–34 years in Coast region. Of concern, we found a significant increase in HIV prevalence among middle-aged and older women (aged ≥35 years) residing in Central region.

Reductions in HIV prevalence on a population level is possible if there are marked declines in new HIV infections or high rates of HIV-related death in a population. If substantial, both scenarios on their own could result in a diminished pool of infected people in the population. Over the past 5 years, Kenya has experienced substantial progress in linking HIV-infected persons into HIV care and placing those that require ART on treatment.<sup>12</sup> Increased coverage of ART and high levels of viral suppression on ART have led to significant reduc-

tions in HIV mortality and HIV transmission risk, likely contributing to a possible decline in HIV incidence over the past 5 years.<sup>1,12</sup> Still, over half of HIV-infected persons in the country remained undiagnosed by the year-end (2012), representing a major barrier to achieving even greater reductions in HIV transmission to eventually halt the spread of infection.<sup>13</sup> A critical component to reversing this trend will be to accelerate ART coverage in the country by prioritizing HIV testing in settings that will yield greater numbers of HIV-infected persons, facilitating their immediate linkages into HIV care services, and treating them promptly.

Our findings provide important insight on groups with increased risk of transmitting HIV to sexual partners, highlighting opportunities for targeted HIV prevention. Markers of high-risk sexual behaviors, including multiple sexual partners and perceived risk of HIV infection were associated with higher odds of undiagnosed HIV infection. Surprisingly, we found that persons who used a condom with their last sexual partner in the past 12 months had higher odds of undiagnosed HIV infection. This positive association may be a reflection of reluctance or denial in admitting to unprotected sex. Alternatively, it could suggest that persons who choose to use condoms with their sexual partners may already know that they are at high risk of HIV infection despite lack of awareness of their HIV infection. The use of condoms in this group is an encouraging finding for HIV-positive prevention strategies but raises the question as to whether current condom use campaigns are effective in reaching the general population with messages on the important benefits of correct and consistent condom use for HIV prevention.

Widowhood has been previously described as a factor associated with HIV infection in Kenya and other countries in sub-Saharan Africa although the factors that place widowed men at higher risk of HIV infection are not clear-cut.<sup>14–18</sup> Widowers whose spouses died of HIV disease may have been exposed to high viral load from their partners, which can occur during late-stage disease,<sup>17</sup> but it is also possible that widowed men were sources of infection for their spouses who died from the disease. Studies

**TABLE 3.** Trends in HIV Prevalence by Region, Residence, and Age Group, KAIS 2007 and KAIS 2012

	Persons Aged 15–24 Years				Persons Aged 25–34 Years			
	Men		Women		Men		Women	
	KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)	KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)	KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)	KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)
Total	1.0 (0.9 to 1.9)	1.1 (0.5 to 1.8)	5.6 (4.6 to 6.6)	3.0 (2.2 to 3.8)†	8.1 (6.5 to 9.7)	5.4 (3.9 to 6.8)‡	12.0 (10.3 to 13.7)	7.3 (6.0 to 8.7)†
Region*								
Nairobi	0.5 (0 to 1.4)	2.2 (0 to 4.6)	5.8 (2.2 to 9.3)	1.8 (0.4 to 3.2)‡	7.0 (2.7 to 11.3)	2.8 (0.6 to 5.1)	14.0 (10.3 to 17.7)	6.6 (3.8 to 9.5)‡
Central	0.9 (0 to 2.0)	0.9 (0 to 2.7)	1.7 (0.5 to 2.9)	1.0 (0 to 2.5)	4.5 (0.3 to 8.7)	2.0 (0 to 4.3)	7.7 (3.5 to 11.9)	4.5 (2.2 to 6.9)
Coast	4.5 (0.9 to 8.2)	0.5 (0 to 1.5)‡	5.7 (3.2 to 8.2)	2.0 (0 to 4.1)‡	7.1 (3.2 to 11.1)	0.6 (0 to 1.9)‡	11.6 (6.9 to 16.4)	4.1 (1.9 to 6.3)‡
Eastern	0.6 (0 to 1.4)	1.1 (0 to 3.2)	4.3 (2.2 to 6.3)	0.6 (0 to 1.6)†	3.0 (0 to 6.2)	2.1 (0 to 4.7)	8.9 (5.4 to 12.5)	5.5 (3.0 to 7.9)
Nyanza	1.6 (0.4 to 2.8)	2.0 (0.2 to 3.8)	13.2 (9.6 to 16.9)	10.0 (6.3 to 13.6)	21.1 (14.9 to 27.3)	22.4 (13.8 to 31.0)	24.5 (19.7 to 29.3)	22.9 (15.1 to 30.7)
Rift Valley	1.1 (0 to 2.3)	0.6 (0 to 1.7)	2.9 (1.3 to 4.6)	2.1 (0.7 to 3.4)	8.6 (5.5 to 11.7)	4.9 (2.1 to 7.7)	11.2 (6.9 to 15.5)	4.0 (2.0 to 6.1)‡
Western	2.8 (0.9 to 4.7)	0.9 (0 to 2.3)	4.3 (2.0 to 6.5)	2.2 (0.3 to 4.2)	7.8 (2.3 to 13.2)	4.9 (0.6 to 9.2)	6.9 (3.5 to 10.2)	6.0 (2.8 to 9.1)
Residence								
Rural	1.4 (0.8 to 2.0)	0.4 (0 to 0.9)‡	5.7 (4.5 to 6.9)	2.8 (1.7 to 3.8)†	8.0 (6.2 to 9.8)	4.9 (2.7 to 7.1)‡	11.4 (9.6 to 13.2)	6.3 (4.7 to 8.0)†
Urban	1.3 (0.3 to 2.3)	2.3 (0.8 to 3.9)	5.4 (3.3 to 7.4)	3.3 (2.0 to 4.6)	8.5 (5.3 to 11.7)	5.8 (3.9 to 7.7)	13.5 (9.7 to 17.3)	8.7 (6.4 to 11.1)‡
					Persons Aged 35+ Years			
			Men		Women			
			KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)	KAIS 2007* % (95% CI)	KAIS 2012 % (95% CI)		
Total			7.3 (6.2 to 8.4)	6.4 (5.1 to 7.6)	8.6 (7.3 to 9.8)	9.3 (8.3 to 11.3)		
Region*								
Nairobi			12.6 (5.9 to 19.2)	6.2 (3.2 to 9.2)	13.8 (6.7 to 20.9)	11.6 (7.0 to 16.2)		
Central			4.4 (2.0 to 6.8)	2.5 (0.5 to 4.5)	3.1 (1.8 to 4.4)	8.4 (5.5 to 11.4)‡		
Coast			6.7 (4.1 to 9.2)	5.6 (2.5 to 8.7)	10.6 (7.8 to 13.4)	11.6 (7.1 to 16.2)		
Eastern			3.8 (2.0 to 5.7)	3.0 (1.0 to 5.0)	5.9 (2.7 to 9.0)	8.6 (4.6 to 12.5)		
Nyanza			19.0 (14.2 to 23.9)	19.3 (12.9 to 25.8)	16.9 (13.7 to 20.1)	17.0 (11.4 to 22.7)		
Rift Valley			5.2 (3.4 to 7.1)	4.5 (2.2 to 6.9)	8.0 (4.9 to 11.0)	6.6 (3.8 to 9.4)		
Western			4.5 (2.0 to 7.0)	5.3 (2.2 to 8.4)	6.9 (3.9 to 9.9)	8.6 (4.5 to 12.8)		
Residence								
Rural			7.0 (5.9 to 8.2)	6.1 (4.6 to 7.5)	7.7 (6.6 to 8.9)	8.6 (6.8 to 10.3)		
Urban			8.3 (5.1 to 11.5)	6.9 (4.4 to 9.4)	12.7 (7.7 to 17.7)	13.1 (10.1 to 16.2)		

\*The North Eastern region was excluded from the KAIS 2007 sample for comparability to KAIS 2012.

†Z-test statistic used to compare KAIS 2007 and KAIS 2012 prevalence estimate:  $P < 0.001$ .

‡Z-test statistic used to compare KAIS 2007 and KAIS 2012 prevalence estimate:  $0.001 \leq P < 0.05$ .

have also demonstrated that widowers are more likely to engage in high-risk sexual behavior after the death of their spouse and contribute to new HIV infections in the population.<sup>15</sup>

In addition to widowhood, the link between HIV infection and divorce or separation in women sheds additional light on the vulnerability of women in the Kenyan HIV epidemic. Previous studies in sub-Saharan Africa have reported that the dissolution of marriage, through divorce or separation, is often the result of a female’s HIV status within the couple relationship. HIV-infected women in serodiscordant relationships are more likely to be separated or divorced than HIV-infected men in serodiscordant relationships, reinforcing the gender disparities that exist around sexual norms in the African context.<sup>18</sup> Further exploration of the impact of serodiscordancy on marital outcomes and implications for the spread of HIV may help to understand how to appropriately strategize prevention, care, and treatment services for couples and formerly married individuals.

Male circumcision has been widely cited as a key pillar of HIV prevention that can significantly reduce new HIV infections in a population.<sup>19–21</sup> Because of an aggressive national strategy on male circumcision, which was implemented in 2008, Kenya has observed substantial increases in male circumcision over the past 5 years, increasing from 85.0% in 2007 to 91.2% in 2012.<sup>11</sup> Greatest increases were noted in the 4 priority regions for the national voluntary male medical circumcision program: Nairobi, Nyanza, Rift Valley, and Western regions.<sup>11</sup> However, coverage in traditionally noncircumcising communities, where regional HIV prevalence is highest, still remains far below the national target of 80% of adult men.<sup>22</sup> We found lower odds of HIV infection among circumcised men highlighting that the prevention benefits of this intervention will continue to play an important role in addressing the HIV epidemic in Kenya. Further scale-up of HIV prevention should aim for universal male circumcision accompanied with sexual

**TABLE 4.** Factors Associated With Undiagnosed HIV Infection by Sex, Ever Sexually Active Persons Aged 15–64 Years, KAIS 2012

	Men (N = 4026)				Women (N = 5767)			
	OR (95% CI)	P	AOR (95% CI)	P	OR (95% CI)	P	AOR (95% CI)	P
Sociodemographic characteristics								
Age group, years								
15–19	1.0	—	1.0	—	1.0	—	1.0	—
20–24	3.0 (0.6 to 15.6)	0.202	1.6 (0.3 to 9.3)	0.621	3.4 (1.0 to 11.2)	0.046	2.6 (0.7 to 9.5)	0.149
25–29	7.0 (1.4 to 33.6)	0.016	4.1 (0.7 to 24.3)	0.120	4.4 (1.4 to 14.1)	0.013	3.6 (1.0 to 13.7)	0.057
30–34	8.0 (1.7 to 36.8)	0.008	3.4 (0.5 to 23.1)	0.206	3.3 (1.0 to 11.0)	0.057	3.3 (0.8 to 14.0)	0.099
35–39	5.2 (1.2 to 22.2)	0.028	2.2 (0.3 to 17.5)	0.452	4.9 (1.5 to 16.2)	0.010	4.5 (1.1 to 18.3)	<b>0.037</b>
40–44	8.7 (1.8 to 41.3)	0.007	4.8 (0.7 to 32.5)	0.111	3.7 (1.1 to 12.0)	0.032	2.8 (0.7 to 11.2)	0.135
45–49	11.5 (2.4 to 54.0)	0.002	5.2 (0.8 to 36.1)	0.092	4.4 (1.2 to 16.0)	0.024	3.3 (0.7 to 15.6)	0.129
50–54	7.0 (1.5 to 33.9)	0.015	3.3 (0.5 to 22.8)	0.223	3.3 (0.9 to 11.8)	0.073	3.3 (0.8 to 14.4)	0.107
55–59	5.8 (1.0 to 32.3)	0.046	2.0 (0.3 to 15.7)	0.512	1.8 (0.5 to 7.0)	0.408	1.8 (0.4 to 9.0)	0.478
60–64	3.9 (0.7 to 21.1)	0.109	1.1 (0.1 to 17.0)	0.922	0.7 (0.1 to 4.2)	0.718	0.7 (0.1 to 5.6)	0.761
Highest educational attainment								
No primary education	1.0	—	*	*	1.0	—	1.0	—
Incomplete primary education	1.1 (0.3 to 3.5)	0.934	*	*	1.6 (0.7 to 3.7)	0.268	2.1 (0.9 to 4.6)	0.068
Completed primary education	1.4 (0.5 to 3.7)	0.523	*	*	2.1 (1.2 to 3.8)	0.013	1.6 (0.6 to 4.3)	0.313
Completed secondary education or higher	1.1 (0.5 to 2.8)	0.764	*	*	1.9 (1.0 to 3.3)	0.035	1.7 (0.8 to 3.6)	0.205
Region								
Nairobi	1.0	—	1.0	—	1.0	—	1.0	—
Central	0.3 (0.1 to 0.9)	0.024	0.4 (0.1 to 1.1)	0.072	1.1 (0.6 to 2.1)	0.680	1.4 (0.7 to 2.8)	0.400
Coast	0.5 (0.2 to 1.2)	0.128	0.6 (0.2 to 1.7)	0.321	1.4 (0.8 to 2.6)	0.268	2.0 (1.0 to 4.1)	0.061
Eastern North	0.3 (0.1 to 1.2)	0.091	0.4 (0.1 to 1.8)	0.251	0.6 (0.2 to 1.5)	0.282	1.3 (0.4 to 3.8)	0.666
Eastern South	0.6 (0.2 to 1.7)	0.303	0.8 (0.3 to 2.4)	0.667	1.0 (0.4 to 2.1)	0.915	1.0 (0.4 to 2.4)	0.933
North Rift	0.7 (0.3 to 1.7)	0.402	0.7 (0.3 to 1.8)	0.485	1.1 (0.5 to 2.2)	0.878	1.0 (0.4 to 2.8)	0.965
Nyanza	3.1 (1.6 to 6.0)	<0.001	2.1 (0.9 to 4.7)	0.074	2.9 (1.6 to 5.0)	<0.001	2.9 (1.4 to 6.0)	<b>0.004</b>
South Rift	0.6 (0.2 to 1.4)	0.222	0.6 (0.2 to 2.1)	0.448	0.6 (0.3 to 1.2)	0.154	1.6 (0.7 to 3.6)	0.219
Western	0.7 (0.3 to 1.6)	0.393	0.6 (0.3 to 1.5)	0.286	0.9 (0.5 to 1.7)	0.770	1.6 (0.7 to 3.6)	0.291
Residence								
Rural	1.0	—	*	*	1.0	—	1.0	—
Urban	1.2 (0.7 to 1.9)	0.513	*	*	1.5 (1.1 to 2.1)	0.014	1.8 (1.1 to 2.7)	<b>0.012</b>
Wealth index								
Poorest	1.0	—	*	*	1.0	—	1.0	—
Second	1.7 (0.8 to 3.3)	0.138	*	*	1.4 (0.9 to 2.4)	0.153	1.0 (0.6 to 1.9)	0.913
Third	1.3 (0.7 to 2.6)	0.433	*	*	1.4 (0.8 to 2.5)	0.243	1.3 (0.7 to 2.3)	0.454
Fourth	1.6 (0.8 to 3.3)	0.165	*	*	2.1 (1.2 to 3.6)	0.009	1.4 (0.7 to 2.7)	0.364
Richest	1.3 (0.6 to 2.8)	0.435	*	*	1.4 (0.8 to 2.4)	0.254	0.8 (0.4 to 1.8)	0.599
Marital status								
Never married/never cohabited	1.0	—	1.0	—	1.0	—	1.0	—
Ever widowed	9.9 (4.2 to 23.0)	<0.001	8.1 (1.9 to 34.6)	<b>0.005</b>	2.0 (1.1 to 3.7)	0.022	2.2 (0.9 to 5.5)	0.080
Separated or divorced	3.7 (1.4 to 9.8)	0.008	2.5 (0.7 to 9.3)	0.157	3.3 (1.9 to 5.8)	<0.001	2.3 (1.1 to 5.0)	<b>0.033</b>
Currently married or cohabiting—polygamous	4.2 (1.6 to 11.4)	0.004	1.3 (0.3 to 6.2)	0.749	1.3 (0.7 to 2.5)	0.383	1.0 (0.4 to 2.6)	0.921
Currently married or cohabiting—monogamous	3.1 (1.6 to 6.0)	<0.001	2.8 (0.9 to 8.6)	0.065	0.8 (0.5 to 1.4)	0.410	0.8 (0.4 to 1.7)	0.626
Behavioral indicators								
Lifetime number of partners								
1	1.0	—	1.0	—	1.0	—	1.0	—
2–3	2.2 (1.0 to 5.0)	0.050	1.8 (0.6 to 5.4)	0.263	1.9 (1.2 to 2.8)	0.002	1.3 (0.8 to 1.9)	0.261

(continued on next page)

**TABLE 4.** (Continued) Factors Associated With Undiagnosed HIV Infection by Sex, Ever Sexually Active Persons Aged 15–64 Years, KAIS 2012

	Men (N = 4026)				Women (N = 5767)			
	OR (95% CI)	P	AOR (95% CI)	P	OR (95% CI)	P	AOR (95% CI)	P
4+	3.3 (1.4 to 8.1)	0.008	2.3 (0.8 to 7.0)	0.128	3.5 (2.2 to 5.5)	<0.001	1.9 (1.1 to 3.4)	<b>0.026</b>
Do not know	5.9 (2.3 to 15.1)	<0.001	2.7 (0.7 to 10.1)	0.135	2.3 (1.1 to 4.6)	0.022	1.4 (0.6 to 3.3)	0.390
Used a condom with last partner in the past 12 mo								
No	1.0	—	1.0	—	1.0	—	1.0	—
Yes	1.8 (1.1 to 2.9)	0.013	3.3 (1.8 to 6.2)	<b>&lt;0.001</b>	2.5 (1.7 to 3.8)	<0.001	2.3 (1.2 to 4.2)	<b>0.009</b>
Not sexual active in the past 12 mo	0.7 (0.3 to 1.3)	0.256	1.6 (0.6 to 4.0)	0.332	1.8 (1.2 to 2.5)	0.003	1.3 (0.7 to 2.5)	0.340
HIV risk perception								
No risk	1.0	—	1.0	—	1.0	—	1.0	—
Low risk	1.6 (0.9 to 2.9)	0.107	1.3 (0.7 to 2.3)	0.444	1.3 (0.8 to 2.0)	0.311	1.3 (0.8 to 2.1)	0.249
Moderate risk	1.6 (0.7 to 3.8)	0.235	0.8 (0.3 to 2.1)	0.718	2.5 (1.5 to 4.1)	<0.001	2.1 (1.3 to 3.5)	<b>0.002</b>
Great risk	3.3 (1.3 to 8.3)	0.011	2.3 (0.8 to 6.6)	0.122	2.1 (1.1 to 4.0)	0.028	1.6 (0.8 to 3.2)	0.192
Most-at-risk behaviors								
Ever injected drugs for pleasure								
No	1.0	—	*	*	—	—	—	—
Yes	3.5 (0.5 to 25.9)	0.215	*	*	—	—	—	—
Ever had anal sex								
No	1.0	—	*	*	1.0	—	1.0	—
Yes	1.2 (0.4 to 3.6)	0.759	*	*	2.3 (1.0 to 5.3)	0.059	1.7 (0.6 to 4.6)	0.281
Ever received money, gifts, or goods in exchange for sex								
No	1.0	—	*	*	1.0	—	*	*
Yes	1.4 (0.6 to 3.4)	0.476	*	*	1.4 (0.7 to 2.9)	0.340	*	*
Ever gave money, gifts, or goods in exchange for sex (men only)								
No	1.0	—	*	*	—	—	—	—
Yes	1.0 (0.6 to 1.7)	0.986	*	*	—	—	—	—
Biologic indicators								
STI symptoms in the past 12 mo								
No	1.0	—	1.0	—	1.0	—	*	*
Yes	3.6 (1.7 to 7.6)	<0.001	1.6 (0.7 to 3.8)	0.280	1.3 (0.7 to 2.4)	0.386	*	*
Ever been tested for HIV								
No	1.0	—	*	*	1.0	—	*	*
Yes	1.1 (0.7 to 1.7)	0.740	*	*	1.0 (0.6 to 1.5)	0.876	*	*
Male circumcision status (men only)								
No	1.0	—	1.0	—	—	—	—	—
Yes	0.1 (0.1 to 0.2)	<0.001	0.3 (0.1 to 0.5)	<b>&lt;0.001</b>	—	—	—	—
Male partner circumcised (women only)								
No	—	—	—	—	1.0	—	1.0	—
Yes	—	—	—	—	0.4 (0.3 to 0.6)	<0.001	0.7 (0.4 to 1.1)	0.106

\*Indicates variable not retained in final multivariate model.

Bolded results were statistically significant findings at  $P < 0.05$  in the final multivariate model.

AOR, adjusted odds ratio; OR, odds ratio.

risk reduction strategies for greater impact in the longer term.

Our results provided important information on geographic areas which require specialized attention for HIV

prevention. Continued momentum is needed to address persistently high levels of HIV infection in Nyanza region. Moreover, the observed increases in HIV prevalence among middle-aged and older women in Central region,

as well as elevated risk of HIV infection among women in urban residences, are areas which require more focused strategies.

Our study had several limitations. Because this study was cross-sectional in design, we were unable to infer directionality of associations, such as the associations between HIV infection and condom use with last sexual partner, widowhood among men, and divorce or separation among women. Behaviors, circumcision status, and symptoms of STI were self-reported, and associations observed may have been impacted by social desirability bias. Selection bias may have been introduced by decisions to exclude North Eastern region from the sampling frame because of security concerns. The North Eastern region, however, is relatively sparsely populated and had an HIV prevalence of only 0.8% in KAIS 2007,<sup>5</sup> and we feel it is unlikely that excluding this region affected our results substantially. Differences in HIV prevalence between KAIS 2007 and KAIS 2012 could also reflect changes in composition of the sample between the two surveys. Compared with KAIS 2007, the sample in KAIS 2012 had significantly higher proportions of persons who were aged 25–34 years, never married or never cohabited, reported secondary education or higher and were from urban residences.<sup>7</sup> The demographic, behavioral, and biological differences observed among KAIS 2012 participants in the interview and serologic sample may have also contributed to either an underestimation or overestimation of HIV prevalence in 2012, limiting our ability to accurately interpret trends in HIV prevalence.

Despite these limitations, KAIS 2012 was a large representative study whose primary findings were based on biological samples obtained during the survey. We believe that evidence of decreasing HIV prevalence to be encouraging yet underscores the need to establish routine and standardized surveillance methods to monitor trends in recently acquired HIV infections and HIV-related mortality for a clearer interpretation of the epidemiology of HIV in the country. Our data support that substantial interventions are needed to improve identification of HIV-infected persons to effectively reach those in need of ART for improved survival and continued reductions in transmission risks. Continued monitoring of the burden of HIV disease through enhanced surveillance and seeking to assess and respond to factors associated with undiagnosed HIV infection are central to an effective response to the HIV epidemic in Kenya.

#### ACKNOWLEDGMENTS

*The authors thank the fieldworkers and supervisors for their excellent work during KAIS data collection and all the individuals who participated in this national survey. The authors also thank Timothy Kellogg for his statistical input; George Rutherford and Joy Mirjahangir for discussing and reviewing the article; Anthony Gichangi, John Bore, James Ng'ang'a, Ray Shiraishi, Eddas Bennett, and Paul Stupp for their input in weighting of the data set; and the KAIS Study Group for their contribution to the design of the survey and collection of the data set: Willis Akhwale, Sehin Birhanu, John Bore, Angela Broad, Robert Buluma, Thomas Gachuki, Jennifer Galbraith, Anthony Gichangi, Beth Gikonyo, Margaret Gitau, Joshua Gitonga, Mike Grasso, Malayah Harper,*

*Andrew Imbwaga, Muthoni Junghae, William Maina, Nicolas Muraguri, Mutua Kakinyi, Samuel Mwangi Kamiru, Nicholas Owenje Kandege, Lucy Kanyara, Yasuyo Kawamura, Timothy Kellogg, George Kichamu, Andrea Kim, Lucy Kimondo, Davies Kimanga, Elija Kinyanjui, Stephen Kipkerich, Danson Kimutai Koske, Boniface O. K'Oyugi, Veronica Lee, Serenita Lewis, William Maina, Ernest Makokha, Agneta Mbithi, Joy Mirjahangir, Ibrahim Mohamed, Rex Mpazanje, Silas Mulwa, Nicolas Muraguri, Patrick Murithi, Lilly Muthoni, James Mutunga, Jane Mwangi, Mary Mwangi, Sophie Mwanyumba, Francis Ndichu, Anne Ng'ang'a, James Ng'ang'a, John Gitahi Ng'ang'a, Lucy Ng'ang'a, Carol Ngare, Bernadette Ng'eno, Inviolata Njeri, David Njogu, Bernard Obasi, Macdonald Obudho, Edwin Ochieng, Linus Odawo, Jacob Odhiambo, Caleb Ogada, Samuel Ogola, David Ojaka, James Kwach Ojwang, George Okumu, Patricia Oluoch, Tom Oluoch, Kenneth Ochieng Omondi, Osborn Otieno, Yakubu Owolabi, Bharat Parekh, George Rutherford, Sandra Schwarcz, Shahnaaz Shariff, Victor Ssempijja, Lydia Tabuke, Yuko Takenaka, Mamo Umuro, Brian Eugene Wakhutu, Wanjiru Waruiru, Celia Wandera, John Wanyungu, Anthony Waruru, Paul Waweru, Larry Westerman, and Kelly Winter.*

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