Preventing Unintended Pregnancy and HIV Transmission: Effects of the HIV Treatment Cascade on Contraceptive Use and Choice in Rural KwaZulu-Natal

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Background: For women living with HIV, contraception using condoms is recommended because it prevents not only unintended pregnancy but also acquisition of other sexually transmitted infections and onward transmission of HIV. Dual-method dual-protection contraception (condoms with other contraceptive methods) is preferable over single-method dual-protection contraception (condoms alone) because of its higher contraceptive effectiveness. We estimate the effect of progression through the HIV treatment cascade on contraceptive use and choice among HIV-infected women in rural South Africa.

Methods: We linked population-based surveillance data on contraception collected by the Wellcome Trust Africa Centre for Health and Population Studies to data from the local antiretroviral treatment (ART) program in Hlabisa subdistrict, KwaZulu-Natal. In bivariate probit regression, we estimated the effects of progressing through the cascade on contraceptive choice among HIV-infected sexually active women aged 15–49 years (N = 3169), controlling for a wide range of potential confounders.

Findings: Contraception use increased across the cascade from <40% among HIV-infected women who did not know their status to >70% among women who have been on ART for 4–7 years. Holding other factors equal (1) awareness of HIV status, (2) ART initiation, and (3) being on ART for 4–7 years increased the likelihood of single-method/dual-method dual protection by the following percentage points (pp),

compared with women who were unaware of their HIV status: (1) 4.6 pp (P = 0.030)/3.5 pp (P = 0.001), (2) 10.3 pp (P = 0.003)/5.2 pp (P = 0.007), and (3) 21.6 pp (P < 0.001)/11.2 pp (P < 0.001).

Conclusions: Progression through the HIV treatment cascade significantly increased the likelihood of contraception in general and contraception with condoms in particular. ART programs are likely to contribute to HIV prevention through the behavioral pathway of changing contraception use and choice.

Key Words: unintended pregnancy, HIV, AIDS, reproductive health, contraception, condoms, HIV transmission

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INTRODUCTION

All women have the reproductive health rights "to decide freely and responsibly on the number and spacing of their children and to have access to the information, education, and means to enable them to exercise these rights."[1] For all women, the ability to freely choose the method of contraception that best fulfills her individual reproductive health needs and wants is an essential component of these rights.[2] Among women living with HIV, prevention of unintended pregnancy is an effective approach to prevent mother-to-child transmission of the virus.[3] In making contraceptive choices, women living with HIV have to consider a number of risks that are different from those that HIV-uninfected women are facing. Compared with HIV-uninfected women, HIV-infected women are at greater risk of morbidity and mortality during pregnancy and motherhood[4] and are at increased risk of severe illness from sexually transmitted infections (STIs) other than HIV.[5–7] HIV-infected women also face the risk of superinfection with a second strain of HIV, which may cause more rapid disease progression and limit treatment options.[8,9] Finally, women living with HIV are at risk of transmitting HIV to their uninfected partners.

Male and female condoms can provide dual protection against unintended pregnancy as well as acquisition and transmission of STIs, including HIV. Other methods of contraception, such as oral and injectable contraceptive drugs and male or female sterilization can prevent unintended pregnancy but do not serve the additional purpose of protecting against STI acquisition and transmission. Although

condoms alone provide dual-protection, dual-method contraception using both condoms and another method is more effective for preventing unintended pregnancies than condom use alone.

In the following, we will use the term single-method dual protection to indicate condom use alone and dual-method dual protection to indicate concurrent use of condoms and at least one other contraceptive method. We will use the term single protection to indicate contraception without condoms. Although women who are HIV infected can use all of the same contraceptive methods as women who are HIV uninfected, WHO recommends that HIV-infected women use dual protection, and ideally dual-method dual protection to maximize effectiveness in preventing both pregnancy and STI acquisition and transmission.[10]

The large-scale use of antiretroviral treatment (ART) has changed what it means to live with HIV and to live in one of the communities in sub-Saharan Africa that are severely affected by the HIV epidemic.[11] ART substantially reduces HIV-related mortality[12] and can dramatically improve life expectancy in communities with high HIV prevalence.[11] By reducing the concentration of HIV in body fluids, ART can also substantially decrease the risk of HIV transmission from an infected to an uninfected partner.[13] Although these biological effects of antiretroviral medication are well established, our knowledge of the behavioral effects of ART programs is limited.

The HIV patient pathway from infection to long-term treatment, the "HIV treatment cascade,"[14] can be divided into several steps. First, an HIV-infected woman learns about her positive HIV status in an HIV testing and counseling session, which typically conveys information about HIV infection, options for long-term care and treatment, the importance of disclosure of HIV status to family members and sexual partners, as well as approaches to prevent onward transmission of HIV.[15] Next, the HIV-infected woman can enroll in pre-ART programs for regular review of ART eligibility, prevention of opportunistic infections, contraceptive counseling, and counseling to prevent onward transmission of HIV.[16–18] At some point after becoming eligible for HIV treatment, the HIV-infected woman may initiate ART; ART initiation is usually preceded by treatment education including information on the importance of ART adherence, disclosure, and practicing safe sex behaviors.[19] Finally, as the HIV-infected woman remains enrolled in the ART program, she will regularly visit ART clinics for assessment of treatment success and continued counseling, including on contraception and prevention of HIV transmission. Progression through the HIV treatment cascade is thus associated with ongoing counseling and knowledge gain on contraceptive choices for HIV-infected women and prevention of HIV transmission. Additionally, the repeated interactions with the health system along the cascade can imply access to contraceptive methods. HIV testing and counseling centers and ART clinics commonly provide male and female condoms, and they are often located close to other health care facilities, such as primary care clinics and family planning centers,[20] where contraceptive methods are available. It is thus plausible that HIV-infected women will increasingly use contraception as they advance from one stage in the cascade to the next. However, the type and magnitude of any such effects is unknown.

Here, we use a rare data opportunity—ART program data that has been linked to population-based surveillance data—to examine whether progression through the HIV treatment cascade affected contraceptive use among the HIV-infected women in a community in rural KwaZulu-Natal with high HIV prevalence[21] and incidence.[22] A previous study in the same community found that ART coverage of HIV-infected populations protected HIV-uninfected individuals from acquiring HIV.[23] In addition to the biological effect of ART, one of the potential causal mechanisms underlying this effect of ART coverage on HIV acquisition could be effects of the ART scale-up on dual protection. To elucidate this possible behavioral pathway from ART scale-up to HIV incidence, we estimate the effects of progression through the HIV treatment cascade on single- and dual-protection contraception.

METHODOLOGY

Setting and Data Collection

We use data collected by the Wellcome Trust Africa Centre for Health and Population Studies (Africa Centre). Since 2000, the Africa Centre has operated a longitudinal Health and Demographic Surveillance System, covering the entire population living in a 438 km^2 surveillance area (about 100,000 individuals) in the rural uMkhanyakude district in northern KwaZulu-Natal, South Africa.[24] HIV prevalence in the adult population in this community was 29% in 2011[21] and incidence has been around 3 per 100 person-years for the last decade,[22] with a slight decline in recent years.[23] ART coverage of all HIV-infected adults in the community has risen from 0% in 2003 to 31% in 2011.[21] The surveillance includes longitudinally linked annual HIV testing but the HIV test results are not provided to the surveillance participants. The people living in the surveillance area can test for HIV free of charge at public-sector HIV testing and counseling centers and primary care clinics. They can also test for HIV in private-sector physician practices and pharmacies. During the individual surveillance interviews, all respondents are asked whether they know their HIV status and all women are asked about their contraceptive use. The surveillance also includes linked longitudinal data on demographic, social, and economic factors. To determine progression through the HIV treatment cascade, we linked the data on clinic visits and ART initiation collected in the local public-sector ART program to the population-based surveillance data, using the South African identification number, first name, last name, and birth dates for linkage.[25]

In 2004, the South African Department of Health in collaboration with the Africa Centre started the Hlabisa HIV Treatment and Care Programme with support from the Presidential Emergency Fund for AIDS Relief (PEPFAR). The program delivers ART through the 17 public-sector primary care clinics in Hlabisa subdistrict. The program provides free HIV testing and counseling, ART, and male and female condoms; it also includes an active pre-ART component enrolling patients for ongoing counseling and monitoring of CD4 count, HIV disease progression, and health status to determine ART eligibility. Before ART initiation, all patients participate in three group sessions and individual counseling.

After initiation, patients with ART make monthly visits to the program to see a nurse and a counselor and to participate in group and individual counseling sessions.[20] Because women who intend to be pregnant or are "not on reliable contraception" should receive a different first-line ART regimen than other patients according to the South African national ART guidelines,[18] contraception and fertility intentions should be part of the conversation that health care providers have with their ART patients during the monthly clinic visits.

TABLE 1. Sample Characteristics

Stage in the HIV treatment cascade	
HIV+, unaware of HIV status	539 (17)
HIV+, awareness of HIV status unknown	292 (9)
HIV+, aware of HIV status	928 (29)
Pre-ART	708 (22)
0–1 years on ART	201 (6)
1–2 years on ART	163 (5)
2–4 years on ART	220 (7)
4–7 years on ART	118 (4)
Age	30.73 (7.80)
Education (in school grades attained)	10.58 (2.81)
Married or in a marriage-like relationship	795 (25)
Distance to nearest primary road, km	5.94 (6.31)
Distance to nearest secondary road, km	1.33 (1.11)
Pregnant at time of surveillance interview	133 (4)
Parity (number of births)	0.28 (0.98)
Health status	
Poor	30 (1)
Fair	570 (18)
Good	262 (8)
Very good	2007 (63)
Excellent	300 (9)
Household wealth quintile	
Poorest	654 (21)
Second	653 (21)
Third	660 (21)
Fourth	654 (21)
Richest	548 (17)
Calendar year	
2005	249 (8)
2006	329 (11)
2007	316 (10)
2008	89 (3)
2009	282 (9)
2010	485 (15)
2011	741 (23)
2012	678 (21)
Sample size (N)	3169

For categorical variables–stage in the HIV treatment cascade, married or in a marriage-like relationship, pregnant, health status, household wealth quintile, and calendar year–the summary statistic shown here is the count of people that fall into a category. The percentage of people in the category is shown in parentheses. For continuous variables–age, education, distance to the nearest primary road, distance to the nearest secondary road, and parity–the summary statistic shown here is the mean. The standard deviation is shown in parentheses. Some of the percentages do not sum up to 100% because the percentages for each category have been rounded to the nearest integer. ART = antiretroviral treatment; km = kilometers; HIV+ = HIV-infected.

Study Population

The study population included all women who met the following eligibility criteria: they were of reproductive age (15–49 years); they had either tested HIV positive in the Africa Centre HIV surveillance or were enrolled in the Hlabisa HIV Treatment and Care Programme; they reported being sexually active within the past year; and they reported on their contraceptive use in the Women's General Health Survey. We used the latest report on contraceptive use available for each woman who met these eligibility criteria. We used data beginning in 2005 because the Hlabisa HIV Treatment and Care Programme started enrolling patients only at the end of 2004.[20] We use data from the observation period 2005–2012.

Contraceptive Use Variables

Until 2009, the field workers in the surveillance inquired about contraceptive use in the individual interviews by asking "Are you currently doing anything, or using any contraceptive method, to delay or avoid getting pregnant?" If a woman answered yes, interviewers asked her to specify which methods she was using; the precoded answer options included the "pill," "intrauterine device," "Depo-Provera injection," "Nur-Isterate injection," "male condom," "female condom," "female sterilization," "male sterilization," and "other." The question changed slightly in 2009. The surveillance interviewers now asked "Have you ever used contraception?" Women who answered yes were then asked "Which method are you currently using?" and could choose among the precoded answer options: "none," "male condom," "female condom," "female sterilization," "male sterilization," "injections," "pill," and "other." One reason for this change in the question was that

TABLE 2. Distribution of Contraceptive Use

	N (%)
No contraception	1468 (46)
Single protection	729 (17)
Injections	546 (17)
Pill	80 (3)
Female sterilization	95 (3)
Male sterilization	11 (0)
Single-method dual protection	777 (26)
Male condom only	741 (23)
Female condom only	29 (1)
Male condom and female condom	7 (<1)
Dual-method dual protection*	195 (6)
Male condom and injections	160 (3)
Male condom and pill	21 (1)
Male condom and female sterilization	6 (<1)
Male condom and male sterilization	2 (<1)
Female condom and injections	6 (<1)
Female condom and pill	1 (<1)
Female condom and female sterilization	0 (0)
Female condom and male sterilization	0 (0)
Sample size (N)	3169

*One individual was using more than 2 types of contraception.

hardly any women interviewed before 2009 had reported intra-uterine device use. As defined above, we categorized the different contraceptive methods into single protection, single-method dual-protection, and dual-method dual-protection contraception (Table 2).

Explanatory Variables

We captured progression through the HIV treatment cascade with dummy variables indicating knowledge of HIV status, enrollment in pre-ART, and having received ART for 0–1, 1–2, 2–4, and 4–7 years. In addition, in the multivariable regression analysis, we controlled for variables that have been found to determine contraceptive use in other studies[26–28]: age, education, relationship status, parity, current pregnancy, self-reported health status, the distance from a woman's place of residence to the nearest primary and the nearest secondary road, household wealth, and calendar year. With the exception of the ART program data (pre-ART and time on ART), all other information, including awareness of HIV status, was collected by the Africa Centre surveillance. We used school grade attainment data to capture education. We coded women as being married or in a marriage-like relationship if she reported that she was married, engaged, or cohabiting. We coded age in years and included age squared to capture non-linear age relationships with contraception use. Following a previous study in this community,[29] we created wealth quintiles based on the ranking of individuals on the first principal component obtained in a principal component analysis of information on 27 household assets, such as vehicles, stoves, beds, and livestock. We included the distances from a woman's place of residence to the nearest primary and the nearest secondary road to capture geographical access to health care, because car ownership is rare in this community and people usually walk to the nearest road to fetch a mini bus to drive to a health care facility.[30]

Analysis

Our primary research question here was whether progression through the HIV treatment cascade affected single- and dual-protection contraception. To answer this question, we chose the bivariate probit model, because the two binary decisions—whether or not to use single-protection contraception (ie, any contraceptive method except for condoms) and whether or not to use single-method dual-protection contraception (ie, condoms)—are likely dependent. We except dependency of the two decisions based on both economic theory (the two contraceptive approaches are imperfect substitutes) and the previous empirical literature.[31,32] In addition to the bivariate probit regression coefficients (Table 3), we estimated average marginal effects (AMEs) for not using any contraception, using single protection, using single-method dual protection, and using dual-method dual protection (Table 4). Conceptually, the AME for a dummy variable, such as one of the variables representing a stage in the HIV treatment cascade, is the average across all the individual marginal effects for that dummy variable for each person in the data set. These individual marginal effects are obtained by

computing each person's probability of having the outcome when the dummy variable is set to zero and when it is set to unity, in both cases keeping the values of all the other explanatory variables to the values given for that person.[33] The AMEs in Table 4 represent the change in the probability of having the outcome when a certain stage of the cascade is reached, compared to the stage that is the reference category. The AME are shown in percentage points (pp). For instance, a woman who has been on ART for 4–7 years is 21.6 pp more likely to use single-method dual protection compared with an HIV-infected woman who does not know her HIV status.

FINDINGS

There were 7443 HIV-infected women aged 15–49 years who participated in the Africa Centre Health and Demographic Surveillance between 2005 and 2012. Of these women, 5510 (74.0%) reported on their sexual activity at least once, and 4625 (83.9%) of the women who reported on their sexual activity had been sexually active within the past year. Among the 4625 women who had been sexually active, data on all variables for the multiple regression analysis were available for 3169 (68.5%). Here, we present the complete-case analyses of this sample of 3169 women.

Table 1 describes the characteristics of the 3169 women in this sample. The majority of the HIV-infected women had not yet enrolled in the ART program (55%). Among the remaining women, half were enrolled in pre-ART and half were on ART. More observations occurred in the latter half of the observation period (68% in 2009–2012) than in the earlier half (32% in 2005–2008). Table 2 shows the distribution of contraceptive methods across the women in this sample of sexually active HIV-infected women; 54% used contraception, and 32% used either single- or dual-method dual protection. Figure 1 shows descriptively contraceptive choice through the HIV treatment cascade. Overall, contraceptive use increased steadily across the stages of the cascade from <40% among HIV-infected women who did not know their status to >70% among women who had received ART for 4–7 years. The increase in contraceptive use occurred largely due to an increase in the use of dually protective methods.

These trends were even more pronounced when we estimated the effect of progression through the HIV treatment cascade on contraceptive use in bivariate probit analysis, controlling for age, education, partnership status, pregnancy status, parity, health status, household wealth, distance to the nearest primary and secondary roads, and calendar year. The coefficient ρ, which measures the correlation between the error terms of the two regressions that we jointly estimated in the analysis, was negative (−0.292) and highly significant ($P < 0.0001$). This correlation confirms that the two contraceptive choices should indeed be jointly estimated because of a relationship between the choices that is not found in the observed explanatory variables. Table 3 shows the regression coefficients and Table 4 the AME from this analysis. Compared with HIV-infected women who were unaware of their positive HIV status, the likelihood of single-method dual protection increased by 4.6 pp when women became aware of their HIV status ($P = 0.030$), by 10.3 pp when they initiated ART

TABLE 3. Effects of Progression Through the HIV Treatment Cascade on Contraception: Bivariate Probit Regression Coefficients Effects

	Single Protection			Single-Method Dual Protection		
	Coefficient	95% CI	*P*	Coefficient	95% CI	*P*
Stage in the HIV treatment cascade						
HIV+, unaware of HIV status	1			1		
HIV+, awareness of HIV status unknown	−0.138	−0.623 to 0.348	0.578	0.410	0.014 to 0.806	0.042
HIV+, aware of HIV status	0.149	−0.011 to 0.308	0.068	0.244	0.092 to 0.396	0.002
Pre-ART	0.161	−0.011 to 0.333	0.067	0.135	−0.034 to 0.305	0.117
0–1 years on ART	0.080	−0.152 to 0.313	0.499	0.439	0.214 to 0.665	<0.001
1–2 years on ART	0.233	−0.014 to 0.480	0.064	0.425	0.178 to 0.671	0.001
2–4 years on ART	−0.032	−0.263 to 0.199	0.785	0.827	0.602 to 1.051	<0.001
4–7 years on ART	0.103	−0.179 to 0.385	0.475	0.903	0.623 to 1.183	<0.001
Age	0.072	0.021 to 0.124	0.006	0.084	0.033 to 0.134	0.001
Age squared	−0.001	−0.002 to 0.000	0.012	−0.002	−0.002 to −0.001	<0.001
Education	0.023	0.002 to 0.043	0.032	0.014	−0.006 to 0.034	0.164
Married or in a marriage-like relationship	0.059	−0.061 to 0.179	0.335	−0.026	−0.144 to 0.093	0.671
Pregnant	−0.481	−0.782 to 0.180	0.002	−0.036	−0.327 to 0.255	0.809
Parity	0.051	−0.006 to 0.108	0.082	−0.085	−0.146 to −0.023	0.007
Health						
Poor health	1			1		
Fair health	−0.091	−0.602 to 0.420	0.726	0.180	−0.369 to 0.729	0.520
Good health	−0.089	−0.630 to 0.451	0.746	0.045	−0.527 to 0.616	0.878
Very good health	−0.050	−0.554 to 0.454	0.847	0.217	−0.325 to 0.758	0.432
Excellent health	−0.404	−0.953 to 0.146	0.150	0.312	−0.254 to 0.878	0.280
Household wealth quintile						
Poorest	1			1		
Second	0.050	−0.102 to 0.202	0.520	−0.025	−0.175 to 0.124	0.740
Third	0.034	−0.119 to 0.187	0.659	0.009	−0.140 to 0.158	0.908
Fourth	0.045	−0.110 to 0.200	0.571	−0.056	−0.210 to 0.097	0.472
Wealthiest	−0.105	−0.270 to 0.060	0.213	0.107	−0.053 to 0.267	0.189
Distance to nearest major road	0.002	−0.006 to 0.009	0.676	−0.012	−0.020 to −0.004	0.003
Distance to nearest secondary road	0.000	−0.044 to 0.043	0.991	0.007	−0.036 to 0.050	0.747
Calendar year						
2005	1			1		
2006	−0.182	−0.708 to 0.343	0.496	0.495	0.059 to 0.931	0.026
2007	−0.220	−0.754 to 0.315	0.421	0.635	0.195 to 1.074	0.005
2008	−0.637	−1.305 to 0.030	0.061	0.936	0.442 to 1.430	<0.001
2009	0.606	0.056 to 1.156	0.031	0.497	0.030 to 0.965	0.037
2010	0.473	−0.068 to 1.015	0.087	0.647	0.193 to 1.102	0.005
2011	0.450	−0.088 to 0.987	0.101	0.704	0.255 to 1.153	0.002
2012	0.538	−0.001 to 1.076	0.050	0.475	0.023 to 0.928	0.040
Sample size			3169			
$\rho = -0.292$, $\chi^2 = 80.96$, $P < 0.0001$						

CI = confidence interval; *P* = p value; ART = antiretroviral treatment; HIV+ = HIV-infected.

($P = 0.003$), and by 21.6 pp when they had received ART for 4–7 years ($P < 0.001$). The likelihood of dual-method dual protection increased by 3.5 pp when women became aware of their HIV status ($P = 0.001$), by 5.2 pp when they initiated ART ($P = 0.007$), and by 11.2 pp when they had received ART for 4–7 years ($P < 0.001$).

As robustness checks of the findings presented here, we repeated the analyses with HIV-uninfected women also included in the sample and after multiple imputation of missing covariates among women who reported being sexually active. The findings

from the analysis that includes HIV-negative women are described in detail in the online Appendix (see **Supplemental Digital Content,** http://links.lww.com/QAI/A576), including the full tables with the descriptive statistics and the regression results. This additional analysis has several advantages (large sample size, ability to compare contraceptive choice by HIV status) but it may also suffer from reverse causality bias because contraceptive choice is an important determinant of HIV status. However, the findings based on the sample including both HIV-infected and HIV-uninfected women are essentially the same as

TABLE 4. Effects of Progression Through the HIV Treatment Cascade on Contraception: AME

	No Contraception			Single Protection		
	AME (in pp)	95% CI	*P*	AME (in pp)	95% CI	*P*
Stage in the HIV treatment cascade						
HIV+, unaware of HIV status	Ref			Ref		
HIV+ awareness unknown	−0.078	−0.206 to 0.049	0.228	−0.064	−0.164 to 0.036	0.207
HIV+, aware of HIV status	−0.094	−0.140 to −0.047	<0.001	0.012	−0.028 to 0.052	0.558
Pre-ART	−0.070	−0.122 to −0.019	0.008	0.025	−0.020 to 0.070	0.273
0–1 years on ART	−0.129	−0.195 to −0.063	<0.001	−0.026	−0.081 to 0.029	0.352
1–2 years on ART	−0.156	−0.225 to −0.086	<0.001	0.006	−0.057 to 0.069	0.858
2–4 years on ART	−0.212	−0.273 to −0.151	<0.001	−0.088	−0.134 to −0.043	<0.001
4–7 years on ART	−0.249	−0.318 to −0.180	<0.001	−0.079	−0.136 to −0.021	0.007
Age	−0.037	−0.052 to −0.021	<0.001	0.009	−0.004 to 0.022	0.177
Age squared	0.001	0.000 to 0.001	<0.001	0.000	0.000 to 0.000	0.366
Education	−0.009	−0.015 to −0.002	0.007	0.004	−0.001 to 0.009	0.147
Married or in a marriage-like relationship	−0.007	−0.044 to 0.029	0.689	0.016	−0.015 to 0.047	0.316
Pregnant	0.110	0.020 to 0.200	0.016	−0.098	−0.156 to −0.041	0.001
Parity	0.009	−0.009 to 0.027	0.332	0.019	0.004 to 0.034	0.012
Health status						
Poor health	Ref			Ref		
Fair health	−0.025	−0.190 to 0.139	0.761	−0.035	−0.159 to 0.088	0.575
Good health	0.009	−0.164 to 0.182	0.919	−0.024	−0.156 to 0.108	0.724
Very good health	−0.041	−0.203 to 0.120	0.616	−0.029	−0.162 to 0.103	0.665
Excellent health	−0.003	−0.181 to 0.174	0.970	−0.104	−0.210 to 0.001	0.053
Household wealth quintile						
Wealth quintile 1	Ref			Ref		
Wealth quintile 2	−0.005	−0.051 to 0.040	0.815	0.014	−0.026 to 0.053	0.493
Wealth quintile 3	−0.010	−0.056 to 0.036	0.666	0.007	−0.032 to 0.046	0.718
Wealth quintile 4	0.003	−0.044 to 0.050	0.892	0.015	−0.025 to 0.055	0.461
Wealth quintile 5	−0.004	−0.053 to 0.046	0.885	−0.032	−0.072 to 0.007	0.111
Distance to nearest primary road	0.002	0.000– to 0.005	0.039	0.001	−0.001 to 0.003	0.161
Distance to nearest secondary road	−0.002	−0.015 to 0.012	0.806	−0.001	−0.012 to 0.010	0.904
Calendar year						
2005	Ref			Ref		
2006	−0.093	−0.230 to 0.044	0.185	−0.08	−0.183 to 0.024	0.131
2007	−0.125	−0.260 to 0.009	0.068	−0.098	−0.195 to 0.000	0.049
2008	−0.170	−0.319 to −0.021	0.025	−0.167	−0.238 to −0.096	<0.001
2009	−0.244	−0.371 to −0.117	<0.001	0.070	−0.068 to 0.208	0.323
2010	−0.252	−0.377 to −0.128	<0.001	0.026	−0.099 to 0.151	0.680
2011	−0.265	−0.392 to −0.138	<0.001	0.022	−0.100 to 0.144	0.725
2012	−0.232	−0.365 to −0.098	0.001	0.069	−0.063 to 0.200	0.305
Sample size			3169			

	Single-Method Dual Protection			Dual-Method Dual Protection		
	AME (in pp)	95% CI	*P*	AME (in pp)	95% CI	*P*
Stage in the HIV treatment cascade						
HIV+, unaware of HIV status	Ref			Ref		
HIV+ awareness unknown	0.121	−0.005 to 0.246	0.059	0.022	−0.042 to 0.086	0.498
HIV+, aware of HIV status	0.046	0.005– to 0.088	0.030	0.035	0.014– to 0.056	0.001
Pre-ART	0.019	−0.028 to 0.065	0.431	0.027	0.004– to 0.049	0.021
0–1 years on ART	0.103	0.034 to 0.172	0.003	0.052	0.014 to 0.089	0.007
1–2 years on ART	0.079	0.006 to 0.152	0.034	0.071	0.027 to 0.115	0.002
2–4 years on ART	0.222	0.150 to 0.294	<0.001	0.078	0.037 to 0.120	<0.001
4–7 years on ART	0.216	0.126 to 0.306	<0.001	0.112	0.053 to 0.171	<0.001
Age	0.014	0.000 to 0.027	0.046	0.014	0.008 to 0.020	<0.001

(continued on next page)

TABLE 4. (*Continued*) Effects of Progression Through the HIV Treatment Cascade on Contraception: AME

	Single-Method Dual Protection			Dual-Method Dual Protection		
	AME (in pp)	95% CI	P	AME (in pp)	95% CI	P
Age squared	0.000	−0.001 to 0.000	0.007	0.000	0.000 to 0.000	<0.001
Education	0.001	−0.004 to 0.007	0.598	0.003	0.001 to 0.006	0.007
Married or in a marriage-like relationship	−0.011	−0.043 to 0.020	0.487	0.003	−0.011 to 0.017	0.695
Pregnant	0.023	−0.061 to 0.107	0.589	−0.035	−0.056 to −0.014	0.001
Parity	−0.025	−0.041 to −0.008	0.003	−0.003	−0.010 to 0.004	0.396
Health status						
Poor health	Ref			Ref		
Fair health	0.054	−0.101 to 0.209	0.496	0.007	−0.057 to 0.071	0.828
Good health	0.019	−0.139 to 0.177	0.816	−0.004	−0.066 to 0.058	0.903
Very good health	0.057	−0.082 to 0.196	0.423	0.014	−0.042 to 0.070	0.634
Excellent health	0.119	−0.057 to 0.296	0.184	−0.012	−0.068 to 0.045	0.689
Household wealth quintile						
Wealth quintile 1	Ref			Ref		
Wealth quintile 2	−0.010	−0.050 to 0.030	0.610	0.002	−0.016 to 0.020	0.817
Wealth quintile 3	−0.001	−0.041 to 0.040	0.970	0.004	−0.014 to 0.021	0.686
Wealth quintile 4	−0.017	−0.058 to 0.023	0.400	−0.001	−0.019 to 0.017	0.913
Wealth quintile 5	0.036	−0.010 to 0.082	0.121	0.000	−0.019 to 0.019	0.990
Distance to nearest primary road	−0.003	−0.005 to −0.001	0.005	−0.001	−0.002 to 0.000	0.050
Distance to nearest secondary road	0.002	−0.010 to 0.013	0.771	0.001	−0.004 to 0.006	0.813
Calendar year						
2005	Ref			Ref		
2006	0.148	0.010 to 0.286	0.035	0.024	−0.046 to 0.095	0.502
2007	0.192	0.049 to 0.334	0.008	0.032	−0.044 to 0.107	0.413
2008	0.336	0.169 to 0.503	<0.001	0.001	−0.073 to 0.075	0.976
2009	0.037	−0.097 to 0.172	0.588	0.137	0.025 to 0.249	0.017
2010	0.095	−0.040 to 0.230	0.169	0.131	0.028 to 0.235	0.013
2011	0.118	−0.012 to 0.248	0.075	0.125	0.032 to 0.218	0.008
2012	0.053	−0.074 to 0.180	0.414	0.110	0.019 to 0.201	0.018
Sample size			3169			

CI, confidence interval; Ref, reference category; *P* = p value; AME = average marginal effects; ART = antiretroviral treatment; HIV+ = HIV-infected.

those based on the smaller sample including only HIV-infected women. The findings from the multiply imputed analysis are also similar to those of the main analysis, suggesting that the missing data do not cause significant bias. Finally, changes in the coding and functional forms of the explanatory variables did not lead to any significant changes in the results. We present these additional findings in the online Appendix (see **Supplemental Digital Content,** http://links.lww.com/QAI/A576), where we also describe and interpret how the other explanatory variables affected contraceptive choice.

DISCUSSION

We examine for the first time the effect of progression through the HIV treatment cascade on contraceptive use. Among HIV-infected women, dually protective methods of contraception can prevent unintended pregnancies, HIV transmission, and the acquisition of other STIs. In a poor, rural community in KwaZulu-Natal, South Africa, we find that both overall contraceptive use and dual-protection contraception increased significantly as HIV-infected women moved from earlier to later stages in the treatment cascade.

Descriptively, the probability of contraception increased from <40% among HIV-infected women who did not know their status to >70% among HIV-infected women 4–7 years on ART. Controlling for a wide range of potential confounders of the relationship between the stages of the treatment cascade and contraceptive use, we find that progression through the cascade significantly increased the overall probability of contraception as well as single- and dual-method dual protection.

Although significant increases in dual protection occurred across the entire cascade, these increases were substantially larger after ART initiation compared with the stages in the cascade when women learnt of their HIV status or were enrolled in pre-ART care. The large ART-associated increases are plausible based on several mechanisms. First, in preparation for ART women receive intensive counseling, including on methods to prevent transmission of HIV to sexual partners. Second, women on ART are likely to discuss their contraceptive behaviors and fertility intentions with ART health workers during the routine ART follow-up visits. Health workers should routinely initiate such discussions, because based on the South African national ART guidelines[18] the ART regimen needs to be changed when a woman
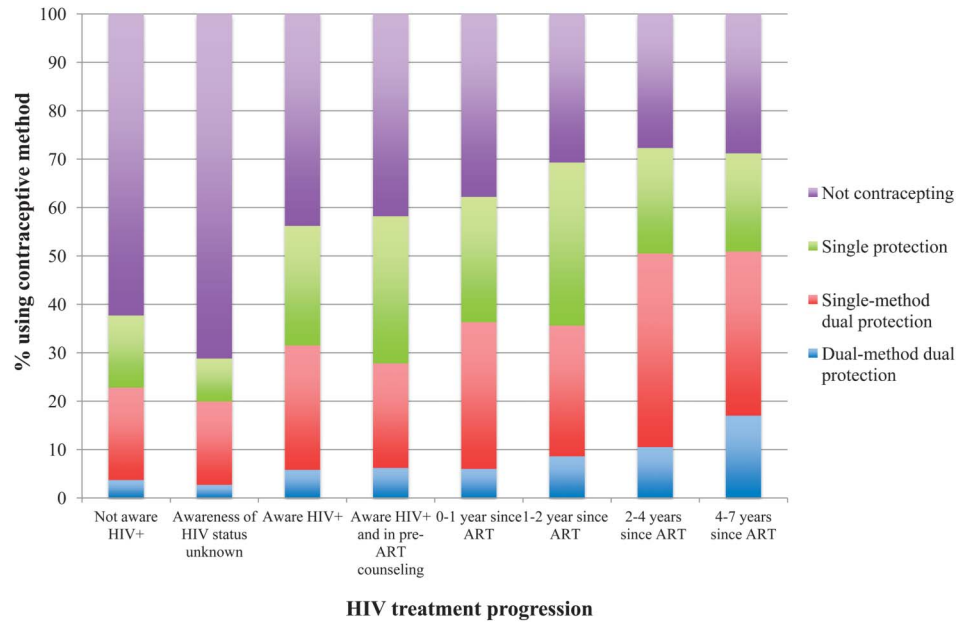
FIGURE 1. Progression through the HIV treatment cascade and contraceptive use.

intends to become pregnant or stops using reliable contraception. These discussions offer repeated opportunities for education on the benefits of contraception with condoms. Third, the ART clinics in this community provide male and female condoms free of charge, so that ART clinic visits imply access to dually protective contraceptives. It is possible that the availability of free condoms in the ART program is a reason for the larger increases observed in single-method dual protection than in dual-method dual protection. Last, the ART clinics are located on the premises of the primary-care clinics and thus in close proximity to family planning and reproductive health services, where contraception information and condoms are available. Future research needs to elucidate whether information and counseling or condom availability is responsible for the large effect of ART on dual protection observed in this study. It will also be important to explore whether more intensive counseling and increased condom availability in HIV testing centers and pre-ART clinic visits could increase use of dually protective methods early in the HIV treatment cascade.

Our results have several important implications for policy and research. First, the ART effects on contraception with condoms could enhance biological treatment-as-prevention effects.[13,23] The effects of progression through the HIV cascade found here could also counteract increased sexual risk taking among HIV-uninfected populations in response to ART scale-up. Such "risk compensation"[34] behavior has been hypothesized because the availability of ART decreases both the risk of contracting HIV through unprotected sex as well as the expected health losses after contracting HIV. However, the evidence on "risk compensation" and its potential consequences for HIV incidence is weak, and it is possible that counteracting factors, such as ART-associated behavior change in HIV-infected people has prevented its manifestation.

Second, despite the significant and large increases in dual protection across the HIV treatment cascade, in all cascade stages large proportions of HIV-infected women continued using only single-protection contraception. Although there are significant effects of learning about one's positive HIV status on both overall contraceptive use and contraception with condoms, these effects are small compared with the effects of ART. Future intervention research is needed to determine how HIV counseling and testing can be enhanced to achieve larger dual-protection effects than currently.

Third, although dual-method dual protection increased as women progressed through the HIV treatment cascade, these increases were small relative to the increases in the use of single-method dual protection, which is not as effective as dual-method dual protection in preventing unintended pregnancy. Future research needs to establish what interventions—for example, targeted provision of contraceptives, new types of contraceptives, or stronger incentives to use contraceptives—can lead to additional condom use among women who currently use other contraceptives and the addition of other contraceptives among women who currently use condoms.

Our study has several strengths but it also has important limitations. One strength of this study is that information about contraception is elicited in the community and not in patient interviews after HIV counseling or visits to an ART clinic, where previous studies have elicited this information.[35−39] Although we cannot rule out social desirability biases, such biases seem much less likely when questions about contraception are asked in patients' homes and as part of an interview on a wide range of issues rather than in clinics after patients have just been counseled on a range of ART-related issues, including on prevention of HIV transmission. Home-based interviews are removed from the social norm-setting context associated with ART and HIV counseling. Additionally, unlike in patient interviews, the fieldworkers conducting home-based interviews are unaware of the HIV status of their interviewees; social norms related to HIV status are thus unlikely to affect responses.

Other strengths of this study include the large sample size and the fact that we could here for the first time directly compare the effects of different important stages across the HIV treatment cascade, including gaining HIV status knowledge, pre-ART, and ART initiation. An important limitation is that we cannot rule out that unobserved confounders have biased the observed relationships between the stages of the cascade and contraceptive choice. One important unobserved factor that could have confounded our results is fertility intention. Fertility intention may decrease when a woman learns about her positive HIV status;[35,36] in this case, the estimated effect of HIV awareness on contraceptive choice found in this study may be an overestimate of the true effect. Conversely, fertility intentions may increase after ART initiation as a woman's health and future outlook improves;[37–39] in this case, the effects of ART on contraception and dual protection found in this study may be underestimates of the true effects. Follow-up studies need to establish causal effects more firmly. Because we cannot randomly assign individuals to different stages in the cascade, quasi-experimental studies will be the only option to strengthen causal inference about the effects of the cascade on contraceptive choice. Examples of quasi-experimental approaches that could be feasible for this purpose include instrumental variable approaches (using, for instance, distance to the nearest ART clinic as an instrument for ART initiation) or regression discontinuity designs using the fact that ART is initiated in patients by applying a threshold rule to the continuous variable CD4 count.[40,41]

CONCLUSIONS

Progression through the HIV treatment cascade significantly increased the likelihood of contraception in general and contraception with condoms in particular. The largest increases in contraception with condoms occurred after ART initiation. Future integration of HIV and reproductive health services can build on these achievements to further increase the use of dual-protection contraception, especially in the early stages of the HIV treatment cascade. Our results further suggest that ART programs contribute to HIV prevention through the behavioral pathway of changing contraception uptake and choice.

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