Love in the Time of HIV: How Beliefs about Externalities Impact Health Behavior

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Abstract

Despite the widespread availability of lifesaving antiretroviral drugs, demand for HIV testing is low. Antiretrovirals have a positive externality: they prevent HIV transmission. We use an experiment in Malawi to show that informing communities about this externality can shift beliefs and increase HIV testing in the short term, with a larger effect for sexually-active demographics. We also see a change in attitudes toward sexual partners taking antiretrovirals. Learning about a positive externality can increase demand for healthcare.

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1 Introduction

More than half a million people died of AIDS in 2019, despite the availability of free, effective treatment. Antiretroviral therapy (ART) suppresses the HIV virus, reverses the symptoms of AIDS, and prolongs life by decades. Over the past two decades the supply of medication has increased, but, demand for HIV testing and treatment is surprisingly low. In 2016, UNAIDS set a "90-90-90" goal for 2020, to diagnose 90 percent of those living with HIV, and treat 90 percent of those diagnosed.[1] This was not achieved, with only two-thirds of people living with HIV on treatment.[2]

ART has a large positive externality: it prevents HIV transmission by suppressing an infected person's viral load. This discovery was Science magazine's "Breakthrough of the Year" in 2011, and prompted a "Treatment as Prevention" strategy to end the epidemic. It is now recognized that delays in diagnosis and treatment lead to more new infections. Yet, in southern Africa there are still nearly one million new infections per year, most of which are sexually transmitted (UNAIDS, 2019). While the private benefits of treatment are widely understood, the positive externality is not.

In this paper we ask whether learning about the positive externality associated with ART can impact demand for HIV testing. Health-seeking behaviors often have positive externalities. Policy can be used to internalize these externalities through subsidies or incentives. A person who learns of an externality might also change behavior to protect others, or to protect their own reputation, especially if behavior is observable.[3] HIV is a stigmatized condition, and getting tested could signal imprudence, immorality or infectiousness. But, this might change if people become aware that treatment prevents HIV transmission.

We used a randomized experiment in Malawi to provide new information, at community meetings, about the fact that ART prevents HIV transmission. We randomly assigned 122 villages to either control or intervention arms. In every village we provided information about the private benefits and availability of ART. In intervention villages, we also provided information on the positive externality. In particular, we informed meeting attendees that ART, when taken correctly, reduces

[1] The final "90" represents viral suppression.

[2] Source: UNAIDS (2019).

[3] See Bénabou and Tirole (2006) for theory of social signalling. Lacetera and Macis (2010), Ashraf et al. (2014) and Karing (2019) show that social signalling can influence health behavior.

HIV transmission by approximately 96 percent (Cohen et al., 2011). This design allows us to isolate the impact of information about the positive externality.

The intervention caused a large and persistent shift in beliefs, and a significant short-term increase in HIV testing. Four months after the experiment, 80 percent of control arm respondents were unaware that treatment could affect transmission, while more than 80 percent of those in the intervention arm believed that ART could prevent transmission. The intervention more than doubled the testing rate within one month. The estimate is larger for demographics likely to be sexually active, and for men, who are less likely to seek care and more likely to die of AIDS (Dovel et al., 2015).

We also observe a change in attitudes toward potential sexual partners who seek HIV care, and a change in perceived community beliefs about transmission. HIV testing is a necessary step toward ART, and, absent externalities, is a signal of infection and infectiousness. However, respondents in the intervention arm were more likely to believe that a person taking ART was less risky than the average person, which is true given high HIV prevalence in the region. They were also more likely to prefer a sexual partner on ART to a partner who has never been tested, and to believe that a person taking ART might find a new sexual partner. Finally, respondents in the intervention arm were aware of the shift in beliefs among their neighbors. Beyond private beliefs about transmission, which might impact HIV testing decisions directly, these changes in perceptions of beliefs and attitudes among peers may help explain the increase in HIV testing we observe.

This paper shows that new information about an externality can affect demand for health care. Our context provides a unique opportunity to study how externalities can impact behavior, because the externality is not obvious. HIV transmission events are rare and imperfectly observed. In many other contexts, externalities are already well understood by the public. Banerjee et al. (2020) find that messaging can affect COVID-19 risk mitigation measures, but emphasizing externalities has no additional impact, perhaps because they are well known.[4] Other successful health information campaigns bundle information about externalities with other information (Grieco et al., 2018; Goeb et al., 2020). Or, they combine information with behavioral interven-

[4]Interventions that encourage people to limit their environmental impact often fail, perhaps for the same reason (Yeomans and Herberich, 2014; Wadehra and Mishra, 2018; Mi et al., 2020).

tions to enable collective action (Gertler et al., 2015; Guiteras et al., 2015). By focusing on an externality that affects sexual partners, we might expect a stronger response, as partners might be able to internalize the externality. For example, Ashraf et al. (2022) find that informing married men about maternal mortality risk causes a decrease in fertility.

We use administrative health records to show that a simple information intervention can increase voluntary HIV testing in the short term. Complete administrative data allows us to capture all tests, as opposed to tests that take place only in the context of a particular study. Moreover, using administrative data allows us to measure true willingness to travel to a clinic and seek a test, without relying on self-reported measures, and without the use of study prompts or vouchers, which might distort testing behavior. Indeed, the 7 percent annual rate of HIV testing we observe in the control arm is lower than levels typically seen in self reports, or when testing is offered directly to participants. For example, Thornton (2008) also finds that HIV testing doubles in response to a small monetary incentive, but from a much higher base of 34 percent. Yet, our data indicates that people rarely seek an HIV test independently, so results from studies that offer testing directly might not scale. On the other hand, while the increase in testing we observe is epidemiologically relevant, many people are left undiagnosed and untreated. Adding information to an existing campaign is typically inexpensive, and an information intervention may be more effective when other barriers to testing are addressed simultaneously. For example, incentives can impact HIV testing not only directly but also through positive spillovers (Thornton, 2008; Godlonton and Thornton, 2012).[5] Banerjee et al. (2019) find that embedding HIV information and behavioral messaging in a television narrative doubles HIV testing. Behavioral nudges such as HIV testing appointments have been shown to triple demand for HIV testing (Derksen et al., 2022a), and adopting performance pay for health providers can also increase HIV testing rates in nearby communities (de Walque et al., 2015).[6]

[5] Godlonton and Thornton (2012) find that a 10 percentage point increase in a neighbor learning HIV test results increases one's probability of learning results by 1.1 percentage points.

[6] de Walque et al. (2015) estimate that performance pay for health providers leads to an 11 percent increase in ever having been tested. The effect of information on HIV care depends on the information content; information on the preventive benefits of circumcision does not appear to affect demand (Chinkhumba et al., 2012; Godlonton et al., 2016).

Finally, we show that providing information on "Treatment as Prevention" affects attitudes towards potential sexual partners who seek HIV care. HIV is a serious and stigmatized sexually transmitted virus.[7] Young and Zhu (2012) describe how HIV test seekers hide the purpose of their visit to avoid stigma, and ART patients who do not disclose their HIV status to their spouses are more likely to lapse from care (Hoffman et al., 2017; Derksen et al., 2022b). Thornton (2008) shows that HIV testing responds to monetary incentives, and argues that such incentives conceal a person's motivation for testing. On the other hand, Angelucci and Bennett (2021) find that when tests are provided routinely to those who have tested negative in the past, frequent testing is viewed positively.

These findings highlight an important tradeoff: while transparency about health measures that reduce risk may lead to risk compensation, it can also increase demand for healthcare. Public health messaging has at times denied or understated risk mitigation measures, for example by emphasizing abstinence over condoms, or, in the case of COVID-19, downplaying the potential for vaccines to prevent transmission. Yet, anti-HIV messaging strategies that focus on abstinence have not been effective (Duflo et al., 2015), and Dupas (2011) shows that people can respond rationally to clear risk information. Moreover, Kerwin (2020) shows that overstating HIV infection risk can in fact increase risk taking. We find that transmission prevention can motivate a person to seek an HIV test. If we obscure the fact that treatment prevents transmission, we might suppress demand for HIV testing and treatment.

The paper proceeds as follows. Section 2 describes the experimental context and design. Section 3 provides a description of the data and results. Section 4 concludes.

2 Background and Experimental Design

2.1 Treatment as Prevention

ART is a medication that suppresses the HIV virus and reverses the progression of AIDS. ART is now widely available for free in Africa, and AIDS mortality has decreased by over 30 percent in the past decade (WHO, 2018). Yet, creating demand for HIV testing and ART remains a policy challenge, and lapses in care are common

[7] See Mahajan et al. (2008) for a review of research on the stigmatization of HIV.

(Derksen et al., 2022b). Genberg et al. (2015) find that barriers to adherence include stigma, time and scheduling issues, as well as side effects of the medication.

ART also prevents HIV transmission between sexual partners by quickly and dramatically suppressing a patient's viral load (Perelson et al., 1997).[8] It is nearly impossible for a virally-suppressed person to transmit HIV (Cohen et al., 2011; Rodger et al., 2016; Bavinton et al., 2018; Rodger et al., 2019). Adherence to ART is imperfect, and not all patients are virally suppressed. However, a large trial conducted primarily in sub-Saharan Africa demonstrates that ART use reduces HIV transmission by 96 percent (Cohen et al., 2011). This does not hinge on perfect adherence, as participants took medication at home, unsupervised, and there was no waiting period after initiating treatment.[9]

Because ART prevents transmission, epidemiological models suggest that universal testing and treatment would end the AIDS epidemic (Granich et al., 2009). However, risk taking may increase in response to treatment (Friedman, 2018). Greenwood et al. (2019) calibrate a general equilibrium model of the epidemic that allows for a behavioral response, and find that infections drop dramatically when more than half of those infected are treated.

The World Health Organization has now adopted a "Treatment as Prevention" strategy, encouraging early ART to prevent new infections. It has also recently led to a global campaign to inform the public that "Undetectable=Untransmittable", a person who is virally suppressed cannot transmit HIV.[10]

2.2 Experiment

Our study took place in 2014 in Zomba District, Malawi, where HIV prevalence is approximately 13 percent (DHS 2015-16). HIV testing and ART are free at clinics.

[8]Viral concentration drops by 99 percent within two weeks of treatment. For this reason, ART also prevents HIV transmission from mother to child, even when initiated late in pregnancy (Group et al., 2011).

[9]ART drugs reduce HIV transmission by at least 96 percent relative to the absolute transmission rate over any time period up to ten years. The absolute transmission rate is low, so the total reduction is approximately linear. Lakdawalla et al. (2006) find that viral load was not widely suppressed among American ART users at the end of the 1990's, which leads to a smaller reduction in infectivity (Porco et al., 2004). However, the antiretroviral regimens used in (Cohen et al., 2011) were standard across many African countries as of 2011, including Malawi.

[10]See, for example, https://www.unaids.org/en/resources/presscentre/featurestories/2018/july/undetectable-untransmittable.

Upon obtaining a positive test, a person can initiate ART immediately or at a later date.[11] Clinics are public spaces, and the decision to test may be observable. The test result, however, is confidential, and a person who tests negative does not receive proof. The private benefits of ART are well understood, but the fact that it prevents HIV transmission is not (Kaler et al., 2016).

Our sample includes 122 villages.[12] At the time of the study the annual testing rate was 7 percent, and fewer than 5 percent of village members were enrolled as ART patients.[13] One third of test seekers travelled further than necessary, possibly to avoid being seen.

We randomly assigned villages to either a control or intervention arm, stratifying on above-median population and district-assigned clinic. This stratification ensures that intervention and control villages are served by the same set of clinics, and that any clinic-level shocks impact both study arms equally. The clinics did not experience any shortage of stock or personnel during the study period, and there were no interruptions in HIV testing or ART provision.

We conducted community education meetings in all villages. We hired HIV testing counsellors with local experience in community outreach to work as educators.

In the control arm we provided information only on the private benefits of ART. Educators started the meeting by asking for a show of hands: 75 percent of attendees believed that ART allowed HIV-positive individuals to lead long and healthy lives. Educators then explained that ART increases life expectancy, reduces symptoms, and is free at clinics. Educators explained how ART works using an infographic depicting a reduction in viral load (Panel A of Figure 1, and an equivalent figure for HIV-positive women).

In the intervention arm we provided information on both the private benefit and positive externality of ART. Community educators started by providing the same information as in the control arm. Next, they asked whether participants believed that ART had an effect on HIV transmission. Only 5 percent raised their hands. We did

[11]At the time of the study, only those with symptoms or a CD4 count below 500 (a measure of immune health) qualified for ART. However, most delay HIV testing until they are experiencing severe symptoms. According to administrative data, during the time of this study 89 percent of patients who attempted to initiate ART qualified. Most countries, including Malawi, have since adopted a policy of universal treatment.

[12]We selected villages based on unique name, to link them to administrative data.

[13]See Section 3.1 for details on our administrative data.

not ask this question in the control arm, to avoid priming respondents by suggesting such an effect might exist. Educators explained that correct adherence to ART reduces the probability of HIV transmission by 96 percent. They used infographics to explain that ART reduces viral load, which reduces transmission (Panel A of Figure 1, and an equivalent figure for HIV-positive women). Educators emphasized the importance of correct adherence. Indeed, ART users do not always practice good adherence, and we were careful not to claim that ART users in general were safe partners.[14]

An intervention script is in Appendix Table A1. The meetings were approximately 45 minutes and balanced in terms of participation (one opportunity to raise hands, and time for clarifying questions). If a participant asked a question not answered by the script, they were referred to their local clinic. Local clinics were not aware of the intervention, and educators had no links to local clinics.

Village chiefs advertised the meetings as "health information meetings", and were not given prior information about the content. Chiefs took attendance, and received small personal gifts of soap and salt.

A total of 14,551 individuals attended a community meeting. The target population was individuals of reproductive age, as defined by the Malawi DHS: women aged 15 to 49 and men aged 15 to 54. In the average village, over two thirds of the target population attended the meeting, and one third of attendees were men. Attendance did not differ by study arm (see Table 1, Panel A).

To avoid educator knowledge effects (Kerwin and Ordaz Reynoso, 2021), we conducted meetings in control villages before training for the intervention. To improve the quality of the intervention, we told the educators that they would receive small incentives based on general knowledge retention in both control and intervention villages.[15]

[14]In Malawi, nearly 90 percent of ART users are virally suppressed (Hosseinipour et al., 2017; UNAIDS, 2019).

[15]Incentives were paid five months after the intervention. The amount was based on the percent of attendees in intervention villages who believed that ART prevents HIV transmisson, and the percent of attendees in control villages who believed that ART had private benefits, according to the survey. The educators did not know how or when we would measure their performance, nor the incentive amount (maximum 100 USD). The survey was conducted by interviewers who did not know the educators and were apparently unaware of the intervention. The interviewers were not members of the study communities, and did not visit the communities after the intervention. However, some educators remained in the village up to 30 minutes past the end of the community meeting, spreading information according to the script to community members. We foresaw this possibility, so it was allowed, and additional participants were recorded as attendees.

3 Empirical Strategy and Results

3.1 Data

We use administrative data from clinics for HIV testing measures and village-level covariates. We use survey data, collected four months after the intervention, to measure beliefs and explore mechanisms.

We did not conduct a baseline survey, or elicit baseline beliefs, to avoid contaminating the control group by mentioning the possibility that ART might prevent HIV transmission. We will see in Section 3.3 that 80 percent of respondents in the control group were unaware of this fact.

We have administrative data on HIV testing and ART patients from all 18 clinics in the study area, including all urban clinics in Zomba Town.[16] We digitized data from handwritten registers from approximately 3 months before to 3 months after the intervention. Registers include sex, age, pregnancy, and village, which allows us to link an HIV test to a study arm. We use GPS coordinates to calculate distances between villages and clinics. Village population was provided by local Health Surveillance Assistants.

HIV testing rates are surprisingly low. Pre-intervention, the annual village-level testing rate was 5 percent. In general, Malawi does not report testing rates based on administrative data, and self-reported testing rates from the Malawi DHS 2015-16 are nearly ten times higher than the rates we observe. So, true rates of diagnosis may be lower than standard country-level estimates suggest.

We use administrative data to show that there is no significant imbalance on village characteristics (see Table 1, Panel A). Yet, control arm villages are, on average, 0.5 kilometers closer to a clinic, and HIV testing and ART use are higher. A joint test (Table 1, Panel A, Column 4) shows that differences in pre-intervention testing are explained by distance-to-clinic. It will be important to control for these covariates in our analysis in order to improve precision and avoid the possibility of capturing mean reversion.

We conducted a survey of 1,343 meeting attendees (approximately 10 percent)

[16]There were no mobile testing campaigns during the study, and self-tests were not yet available, so all HIV tests took place at a clinic. We include clinics within reasonable walking or driving distance of the study villages.

four months after the intervention. Out of 122 study villages, 119 were successfully surveyed.[17] The interviewers were not aware of the intervention. The interviewers selected respondents by conducting a random walk. Two interviewers were assigned to each village; one began the random walk at the center and the other at an outer edge of the village. The interviewers approached each person they encountered, outside or at home, using an attendance sheet to identify meeting attendees. Every person who was asked consented to an interview and received a small gift. There will be selection bias among interviewees, but selection should be the same in control and intervention villages. For example, in both study arms, men represented one third of meeting attendees but only one fifth of survey respondents. Indeed, the sample appears balanced on age, gender and education (see Table 1, Panel B). 82 percent of respondents are female, 40 percent are primary school educated, 75 percent are married and 60 percent are farmers.

3.2 HIV Testing

We first estimate the impact on HIV testing, based on administrative data. For a person infected with HIV, testing is a necessary first step toward treatment. We focus on HIV testing instead of treatment initiation to gain statistical power.

Our intervention is designed to increase HIV testing among a sexually-active population. We therefore focus on individuals of reproductive age, as defined by the Malawi DHS: women aged 15 to 49 and men aged 15 to 54. We also examine two important subgroups. Using the Malawi DHS 2015-16, we identify demographics at high risk of HIV infection (above the national average), and demographics that are likely to be sexually active (the median DHS respondent reports sexual activity in the past week).[18] We do not expect an effect among pregnant women, as they undergo routine testing, but we nevertheless include them as a separate category. We construct our outcomes at the village-month level.

To identify the effect of the intervention on the HIV testing rate, we perform

[17] In one intervention village and two control villages, chiefs denied permission for a survey due to a recent death.

[18] For high-risk demographics, we select 5-year age groups, separately for men and women, for which HIV prevalence is above average. This selects women aged 25 to 49 and men aged 30 to 54. For sexually-active demographics, we select groups for which the median respondent reported sexual activity in the past week. This selects women aged 20 to 44 and men aged 25 to 54.

an ordinary least squares regression.[19] We control for strata (Bruhn and McKenzie, 2009), village-level covariates and month fixed effects.[20]

Our specification is as follows:

$$Percent\ HIV\ tested_{jt} = \alpha + \beta Intervention_j + \boldsymbol{\delta'}\boldsymbol{\chi_j} + \delta_t + \epsilon_{jt}. \tag{1}$$

$Percent\ HIV\ tested_{jt}$ is the percent of the target population in village j who sought a voluntary HIV test in month $t = 1, 2, 3$ after the intervention. Here, $t = 0$ refers to the 25-day experiment period, during which meetings took place. We do not estimate coefficients in the pre-intervention period, as these testing rates are used as covariates. $Intervention_j$ is an indicator for the intervention arm, $\boldsymbol{\chi_j}$ is a vector of covariates including an indicator for strata, pre-intervention testing rate and other village-level covariates listed in Table 1, and δ_t is a month fixed effect. Heteroskedasticity-robust standard errors are clustered at the village level (Abadie et al., 2017).

We also estimate the month-by-month effect, using the following specification:

$$Percent\ HIV\ tested_{jt} = \alpha + \sum_{s=0}^{3} \beta_s \mathbb{1}_{\{s=t\}} * Intervention_j + \boldsymbol{\delta'}\boldsymbol{\chi_j} + \delta_t + \epsilon_{jt}. \tag{2}$$

The intervention caused a significant increase in HIV testing. The effects are concentrated in the first month after the experiment. The intervention more than doubled the rate of HIV testing during this period, and nearly tripled HIV tests among men, with percentage point increases of 0.40 and 0.47 respectively (Figure 2 and Table 2, Panel B). It is not surprising that percentage-point increases are small, as we are comparing to the population-level HIV testing rate in a single month, which is only 0.37 percent. Pooled over three months, the estimated relative effect size is 32 percent, or 0.19 percentage points (Table 2, Panel A). The effects appear larger for men than for women (39 versus 25 percent), and for high-risk and sexually-active populations (50 and 38 percent respectively). While the peak in month one does not rule out persistent effects, as testing is recommended at most every six months, it does suggest that the effect may be concentrated in the short term. There is no significant impact during the experiment period, when meetings were taking place,

[19] Results using weighted least squares are in Table A3 in the appendix.

[20] This estimator is unbiased due to randomization, and has lower variance than a difference-in-difference estimator (McKenzie, 2012).

with slightly higher HIV testing rates in the intervention arm. There is also no impact for pregnant women, who test at a rate of 14 percent per month, consistent with one routine test per pregnancy.

Villages that are closer to clinics and have higher pre-intervention HIV testing rates have significantly higher testing rates post-intervention (see Table A2 in the appendix). Because of a slight imbalance on these variables, it is important to include them as covariates.

To further explore the possibility that the intervention was more effective among those at high risk of infection, we look at the rate of HIV diagnosis. In the control arm, 18 percent of tests were positive. This exceeds local prevalence (13 percent); a person at higher risk of infection is more likely to seek a test. A test seeker in the intervention arm is more likely to test positive than one in the control arm. In the three months after the intervention, 22 percent of HIV tests in the intervention arm were positive. This is consistent with our HIV testing results; the intervention increased testing primarily among high-risk and sexually-active populations. However, our study was not powered to estimate the impact of the intervention on rare outcomes such as new diagnoses or ART initiation.

3.3 Beliefs and Attitudes

We next investigate the effect of the intervention on beliefs about externalities, "placebo" beliefs about HIV, and attitudes toward ART users. Because we provided information at public meetings, the intervention likely impacted not only private beliefs about transmission, but also perceptions of peers' beliefs, as well as attitudes towards HIV care. Private beliefs might affect HIV testing due to prosocial preferences. Changes at the community level might also affect HIV testing by reducing the reputational cost of seeking HIV care. We explore these possibilities using survey data collected four months after the intervention.

We regress each survey measure on the study arm of the village.

$$Belief_{ij} = \alpha + \beta Intervention_j + \delta' \chi_{ij} + \epsilon_{ij} \tag{3}$$

$Belief_{ij}$ is a survey measure from respondent i in village j. $Intervention_j \in \{0, 1\}$ is the indicator for the intervention arm. χ_{ij} is a set of covariates.[21] Heteroskedasticity-robust standard errors are clustered at the village level.

We measured beliefs about treatment externalities in four different ways. First, respondents were read a list of health measures, including ART, and asked to say whether each could prevent HIV transmission. Next, they were asked to agree or disagree with the statement "If an HIV-positive person takes ART it will reduce the chance that he transmits HIV to a partner". Third, we elicited beliefs about the magnitude of the reduction in transmission associated with ART, using ten bottle caps, as advocated by Delavande and Kohler (2009). Each cap represents a serodiscordant couple: an HIV-negative person and their untreated HIV-positive spouse. Respondents were asked to remove one cap for each case of new infection within one year. The process was repeated with a treated spouse. We then calculated beliefs about the relative reduction in risk associated with ART. This measure, in particular, is meant to capture understanding beyond memorization. Finally, we captured beliefs about ART prevention using an infographic (Figure 1, Panel B).

The difference in beliefs, four months after the intervention, is striking. In the control arm, 1 out 5 respondents believed that ART could prevent HIV transmission to any extent. This shows that the information we provided was surprising. The intervention had a large and significant effect on beliefs about the positive externality of ART, according to all four measures (Table 3, Panel A). Respondents in the intervention arm were much more likely to believe that ART could prevent transmission (Columns 1 and 2). On average, control arm respondents believed that ART reduced HIV transmission by 9 or 18 percent, depending on the measure, compared to 52 or 67 percent in the intervention arm (Columns 3 and 4).[22]

Figure 1, Panel B depicts the distribution of beliefs about the reduction in HIV transmission associated with ART, according to the infographic measure. We see that while the intervention shifted beliefs upward, only half of respondents believed that the true reduction in transmission was above 90 percent.

We do not find any impact on other "placebo" beliefs about HIV. Every village

[21]This includes all covariates listed in Table 1 and an indicator for strata. Because we collected survey data after the intervention, we use only age, gender and primary education as individual-level covariates, as these are unlikely to have changed.

[22]These effects do not vary substantially by community educator (Figure A2).

received information about the private benefits of ART, and, in both control and intervention arms, over 98 percent of respondents agreed or strongly agreed that a person taking ART could live a long and healthy life.[23] Neither beliefs about HIV prevalence, nor beliefs about the absolute transmission rate were affected (Table 3, Panel B, Columns 1 and 2).[24]

Finally, we explore one possible mechanism for the increase in HIV testing: a change in attitudes toward potential sexual partners who get tested and treated for HIV. Indeed, we saw a larger increase in testing among sexually-active demographics. HIV is stigmatized, and because testing is a first step toward treatment, it might be viewed as a signal of risk. According to qualitative data from the Malawi Journals Project[25], many seek HIV tests far from home to avoid seeing potential partners. Losing a sexual partner is potentially costly, even for those in other relationships. Concurrent relationships are common in Malawi (Helleringer et al., 2009), and sexual partners are often a source of financial support for women (Baird et al., 2010, 2012; Anderson, 2018).

To shed light on this potential mechanism, we look beyond individual beliefs. First, we ask whether individuals know that the community has updated its beliefs about ART. Second, we ask whether community attitudes have become more favorable toward ART use by potential sexual partners.

The intervention did change perceptions of community beliefs. After using the infographic in Figure 1, Panel B to indicate their own beliefs, each respondent was asked what others in their community believed. Most respondents in the intervention arm are aware that fellow community members know about ART treatment externalities (Table 3, Panel A, Column 5).

The intervention also shifted attitudes toward a partner taking ART. Compared to the control arm, respondents in the intervention arm are nearly twice as likely (30 percentage points) to believe that a person taking ART is a safer sexual partner than a person who has never been tested (Table 3, Panel B, Column 3). They are also 15

[23]This question was asked on a 5-point Likert scale. This is consistent with Baranov and Kohler (2018), who find that ART availability in Malawi increased savings and investment in education.

[24]Beliefs about the absolute probability of HIV transmission are higher than the true value, which, according to the Malawi National AIDS Commission, is approximately 10 percent per year. This is consistent with beliefs reported by Kerwin (2020) in Malawi.

[25]http://malawi.pop.upenn.edu/malawi-data-qualitative-journals

percentage points more likely to prefer a partner taking ART to one who has never been tested, and 10 percentage points more likely to believe that a person taking ART will find a new sexual partner (Columns 4 and 5).

ART greatly reduces HIV transmission risk even for couples who engage in unprotected sexual activity. After providing people with this information, we might expect to see an increase in sexual behavior. In the survey, we collected self-reported measures of sexual activity, recalled over seven days. We find an increase, from 1.6 to 2.2 acts of sexual intercourse (significant at the 10 percent level), and no change in condom use (see Table A4 in the appendix).

4 Conclusion

Informing communities of a positive externality can impact demand for health care. We find that providing new information on the fact that ART prevents HIV transmission increases HIV testing, with a larger increase among demographics likely to engage in sexual activity. This increase is small in absolute terms, but relatively large compared to the rate of HIV testing at baseline. In our sample, approximately half of the infected population is already on ART. Greenwood et al. (2019) estimate that around this level, even a small increase in diagnoses (and treatment) can lead to a sharp reduction in new infections. This is particularly true in this case, as the increase in testing was primarily among sexually-active demographics. At endline, most respondents in the control arm were unaware of a link between ART and HIV transmission. The intervention caused a large shift in beliefs about this externality, and community members were aware of this shift in beliefs among their peers.

Yet, even when both private and public benefits are large and known, communities do not fully internalize the externality. While the increase in testing we observe is epidemiologically relevant, it leaves the majority of the infected population undiagnosed and untreated. Based on prevalence estimates from the Malawi DHS 2015-16 (National Statistical Office/Malawi and ICF, 2017), approximately 7 percent of the population is infected but not treated. Overall testing rates are low, and a monthly increase of 0.19 percentage points is not enough to close this gap, even if it were to persist. We do not estimate longer term impacts as the control group was likely contaminated at the time of the survey, but the effects we estimate are concentrated in the month immediately following the intervention. The experiment took place at a time when treatment eligibility was expanding rapidly. In 2016 it became widely known that anyone could access treatment; this might generate a larger response.

Additional barriers to HIV testing must exist. Testing is negatively correlated with clinic distance.[26] Fear of learning one's status may also play a role (Caplin and Eliaz, 2003; Oster et al., 2013), as a positive diagnosis might impact a person's desire or ability to engage in risky sex.[27] On the other hand, there is near universal demand for door-to-door testing in Malawi (Angotti et al., 2009). Combining information with interventions that remove other barriers to testing may have a larger impact; this remains an important area for research.

We document a change in attitudes toward people seeking HIV care, but this is only one potential explanation for the corresponding increase in HIV testing. Other mechanisms, such as prosocial preferences, salience and peer effects may also play a role. Moreover, learning that treatment prevents transmission might lessen the need to fear an HIV test or avoid knowing one's own HIV status.

We see an increase in sexual activity in response to the intervention. This is consistent with the change in attitudes we observe, and with behavioral responses documented by Oster (2012), Friedman (2018) and Kerwin (2020). ART allows couples to prevent HIV transmission without foregoing sexual activity or the desire to start a family. Indeed, ART is more effective than a condom (Davis and Weller, 1999). Among ART users there would need to be a 25-fold increase in sexual activity to offset the reduction in transmission. ART does not, however, prevent other sexually transmitted infections (Baird et al., 2014; Gong, 2015).

Most countries have adopted a goal of universal testing, and good policy is needed to achieve this goal. Rather than explaining the positive externalities of health care, some public health campaigns inflate perceptions of risk to discourage risk taking. Our results highlight a potential downside of such policies: they may discourage HIV testing. In addition to risky sexual behavior, delays in diagnosis and treatment also perpetuate the spread of HIV.

[26] McLaren et al. (2014) finds the same effect for other health services.

[27] Though, Gong (2015) finds that an HIV diagnosis can lead to more, not less, risky behavior.

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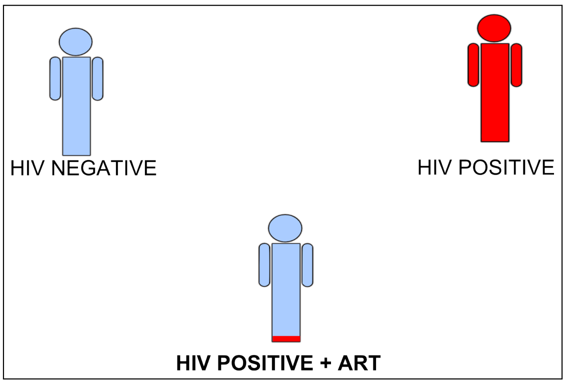
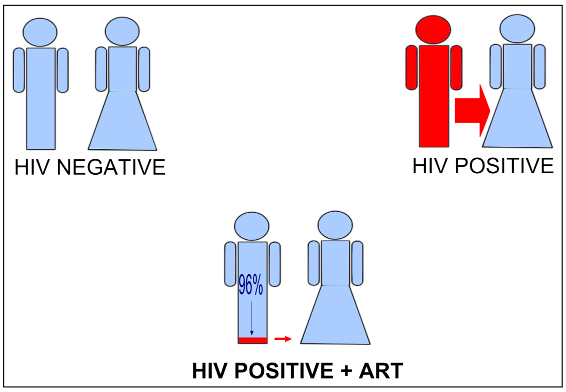
Figures

Figure 1: Infographics and Beliefs

Panel A: Infographics for intervention

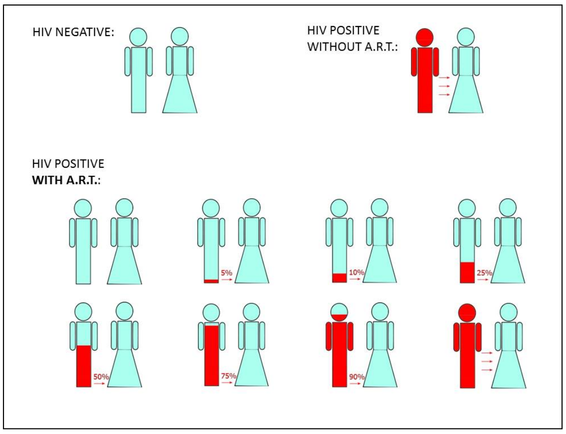


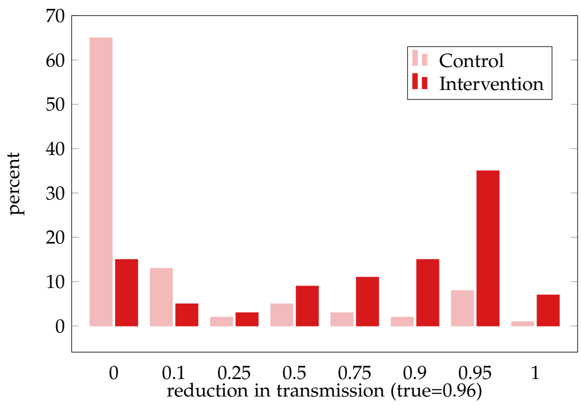
Control arm



Intervention arm

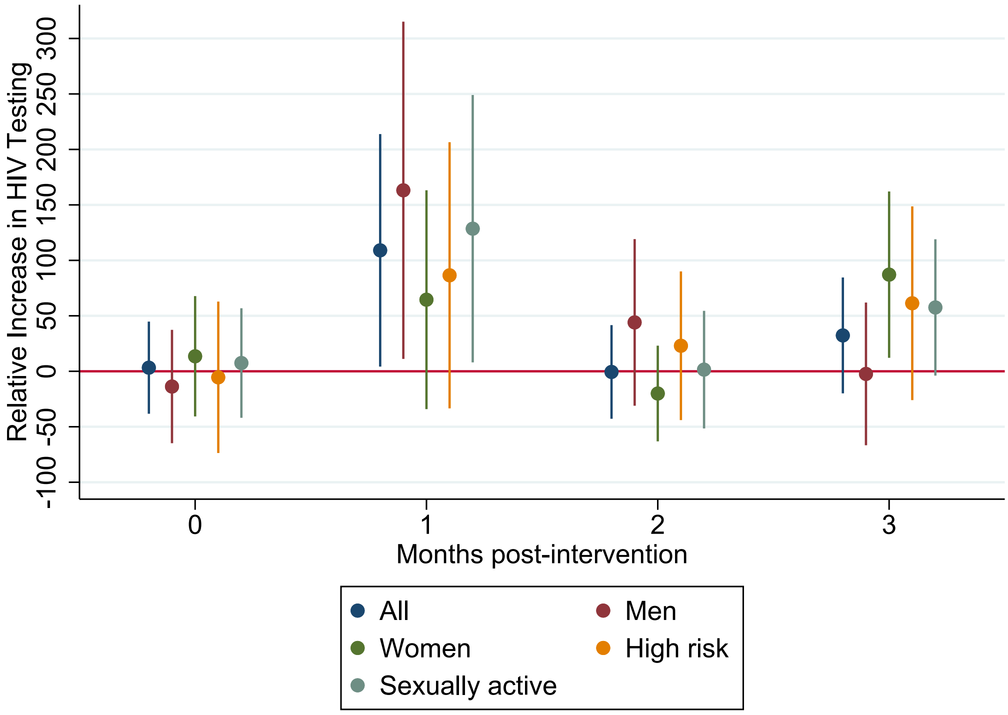
Panel B: Beliefs, 4 months post-intervention





Note: Panel A: The infographics depict viral load with and without ART. The size of the arrow represents HIV transmission risk. Equivalent infographics with an HIV-positive woman were also used at each meeting. Panel B: Beliefs about the reduction in HIV transmission associated with ART were elicited from meeting attendees 4 months after the intervention, using the infographic. Respondents selected the option that was closest to their own belief. The true value is 0.96. The top left corresponds to the belief that an infected person taking ART drugs is not contagious. The bottom right corresponds to the belief that ART drugs have no effect on contagion. The histogram depicts the distribution of beliefs in control and intervention arms.

Figure 2: Percent Tested for HIV per Month Post-Intervention



Note: Administrative data from 18 clinics. Relative increase in HIV testing in intervention arm compared to control arm. This proportional increase is calculated by scaling the estimates in Table 2 by the control-arm testing rate in the same time period. Subgroups are: all reproductive age population as defined by 2015-16 Malawi DHS (non-pregnant women aged 15-49, men aged 15-54), men and non-pregnant women separately within reproductive age population, high-risk population defined as 5-year age groups with >10% HIV prevalence based on 2015-16 Malawi DHS (non-pregnant women aged 30-49, men aged 35-54), sexually-active population defined as 5-year age groups such that median 2015-16 Malawi DHS respondent reported sexual activity in the past week (non-pregnant women aged 20-44, men aged 25-54). Time period 0 is the period during the experiment, and time periods 1,2,3 are months post-intervention. The experiment period, during which control and intervention meetings took place, is 25 days. Regression is OLS at the village-month level, with village-level covariates listed in Table 1, Panel A, time period fixed effects, indicators for stratification bins, and a constant. 95 percent confidence intervals are based on heteroskedasticity-robust standard errors clustered at the village level.

Tables

Table 1: Balance

	(1) Control	(2) Intervention	(3) p-value	(4) p-value (joint test)
Panel A: Village-level covariates (pre-intervention)				
Km to nearest clinic	4.45	5.07	0.148	0.113
% tested per month	0.55	0.37	0.132	0.522
% men tested per month	0.48	0.31	0.196	0.945
% on ART	4.71	3.85	0.173	0.392
Village target population	169	180	0.575	0.290
Meeting attendance	119	120	0.954	0.491
Joint test F-stat				0.117
Observations	62	60		
Panel B: Individual-level covariates (survey 4 months post-intervention)				
Male	0.19	0.18	0.702	0.591
Age	31.2	31.3	0.922	0.807
Completed primary school	0.40	0.41	0.777	0.569
Joint test F-stat				0.905
Observations	681	662		

Note: Panel A: columns (1) and (2) are means across study villages. (3): p-values are for an OLS regression of the covariate on village intervention arm. (4): OLS regression of the intervention indicator on all village-level covariates. (3-4) use heteroskedasticity-robust standard errors. Village target population and HIV testing rates are for those of reproductive age: non-pregnant women aged 15-49, men aged 15-54. Meeting attendance was recorded by the chief before the meeting began. HIV testing rates are monthly based on data from 2.5 months pre-intervention. Panel B: columns (1) and (2) are means across survey respondents. (3): p-values are for an OLS regression of the post-intervention survey response on village intervention arm. (4): OLS regression of the intervention indicator on all individual-level covariates. (3-4) use heteroskedasticity-robust standard errors clustered at the village level.

Table 2: Percent Tested for HIV per Month Post-Intervention

	(1) All	(2) Men	(3) Women	(4) High risk	(5) Sexually active	(6) Pregnant
Panel A: Pooled results (3 months)						
Intervention	0.188**	0.191*	0.174*	0.194*	0.238**	-1.064
	(0.083)	(0.108)	(0.101)	(0.101)	(0.107)	(1.876)
Mean y in control	0.58%	0.49%	0.68%	0.39%	0.62%	14.1%
Proportional increase	32%	39%	25%	50%	38%	-8%
Obs (Village-months)	366	366	366	366	366	366
Panel B: Impact by month post-intervention						
Experiment period	0.028	-0.102	0.136	-0.034	0.074	3.229
	(0.182)	(0.191)	(0.274)	(0.219)	(0.248)	(3.763)
1 month post-intervention	0.401**	0.470**	0.293	0.256	0.475**	-0.354
	(0.195)	(0.221)	(0.226)	(0.179)	(0.225)	(3.138)
2 months post-intervention	-0.004	0.198	-0.220	0.092	0.013	-1.235
	(0.162)	(0.170)	(0.240)	(0.135)	(0.232)	(3.924)
3 months post-intervention	0.200	-0.017	0.436**	0.290	0.359*	-2.151
	(0.163)	(0.236)	(0.190)	(0.209)	(0.194)	(2.623)
Mean y in control, month 1	0.37%	0.29%	0.45%	0.3%	0.37%	11.7%
Proportional increase, month 1	109%	163%	65%	87%	129%	-3%
Village-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs (Village-months)	488	488	488	488	488	488

Note: Administrative data from 18 clinics. Dependent variable: percent (/100) of village population (Malawi National Statistics Office census) tested for HIV post-intervention. (1)-(3): reproductive age population as defined by 2015-16 Malawi DHS (non-pregnant women aged 15-49, men aged 15-54). (4): high-risk population includes 5-year age groups with >10% HIV prevalence based on 2015-16 Malawi DHS (non-pregnant women aged 30-49, men aged 35-54). (5): sexually active population includes 5-year age groups such that median 2015-16 Malawi DHS respondent reported sexual activity in the past week (non-pregnant women aged 20-44, men aged 25-54). The experiment period is 25 days, and the post-intervention periods are each one month. Panel A does not include the intervention period. In Panel B, reported coefficients are for the intervention interacted with time period. (6): pregnant population. Regression is OLS at the village-month level, with village-level covariates listed in Table 1, Panel A, time period fixed effects, indicators for stratification bins, and a constant. Heteroskedasticity-robust standard errors clustered at the village level, in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Beliefs and Attitudes 4 Months Post-Intervention

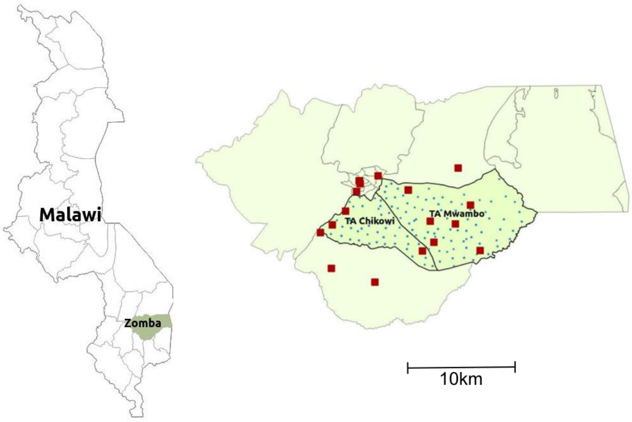
Panel A: *Does ART Reduce HIV Transmission?*					
	(1) Selected ART from list	(2) Likert scale (rescaled 0-1)	(3) Reduction (calculated)	(4) Reduction (infographic)	(5) Perceived beliefs of others
Intervention	0.563***	0.351***	0.430***	0.492***	0.445***
	(0.033)	(0.019)	(0.024)	(0.030)	(0.032)
Mean y in control	0.20	0.44	0.09	0.18	0.15
Obs (Individuals)	1343	1340	1310	1340	1333

Panel B: Other beliefs and attitudes towards ART users					
	(1) Prevalence	(2) HIV transmission rate	(3) Partner taking ART less risky	(4) Prefers untested vs. taking ART	(5) ART user won't find new partner
Intervention	0.002	-0.010	0.299***	-0.149***	-0.100**
	(0.013)	(0.009)	(0.043)	(0.030)	(0.041)
Mean y in control	0.54	0.96	0.42	0.46	0.68
Obs (Individuals)	1224	1330	1341	1224	1276

Note: Survey to meeting attendees approximately 4 months post-intervention. Panel A: (1) selected ART as HIV prevention methods from list: faithfulness, abstinence, ART, circumcision, condoms, mosquito nets. (2): *If an HIV-positive person takes ART it will reduce the chance that he transmits HIV to a partner*. 5-point Likert scale, divided by 5. (3): used ten bottle caps to show beliefs about (a) absolute transmission probability: *Ten couples are serodiscordant (one HIV positive and the other negative). Suppose they do not use condoms or ART drugs. After one year, how many will transmit HIV to their partner?* (b) transmission probability with ART: *Suppose instead that they are all taking ART. How many will transmit HIV to their partner?* These were used to calculate the relative reduction in risk. (4-5): selection from Figure 1, converted into a measure of relative reduction in HIV transmission associated with ART. (4): respondent's own beliefs, (5): what the respondent thinks most members of the village believe. Panel B: (1) used ten bottle caps to show HIV prevalence in the village. (2): used ten bottle caps to show the one-year probability of HIV transmission for a serodiscordant couple who are not using condoms or taking ART. (3): the respondent believes that a person on ART drugs is less likely to transmit HIV than a person who has never been tested. (4): would prefer a partner who has never been tested for HIV to one who is taking ART. (5): believes that a person taking ART will definitely not find a new sexual partner. OLS with a constant and all covariates from Table 1, indicators for stratification bins. Heteroskedasticity-robust standard errors clustered at village level, in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

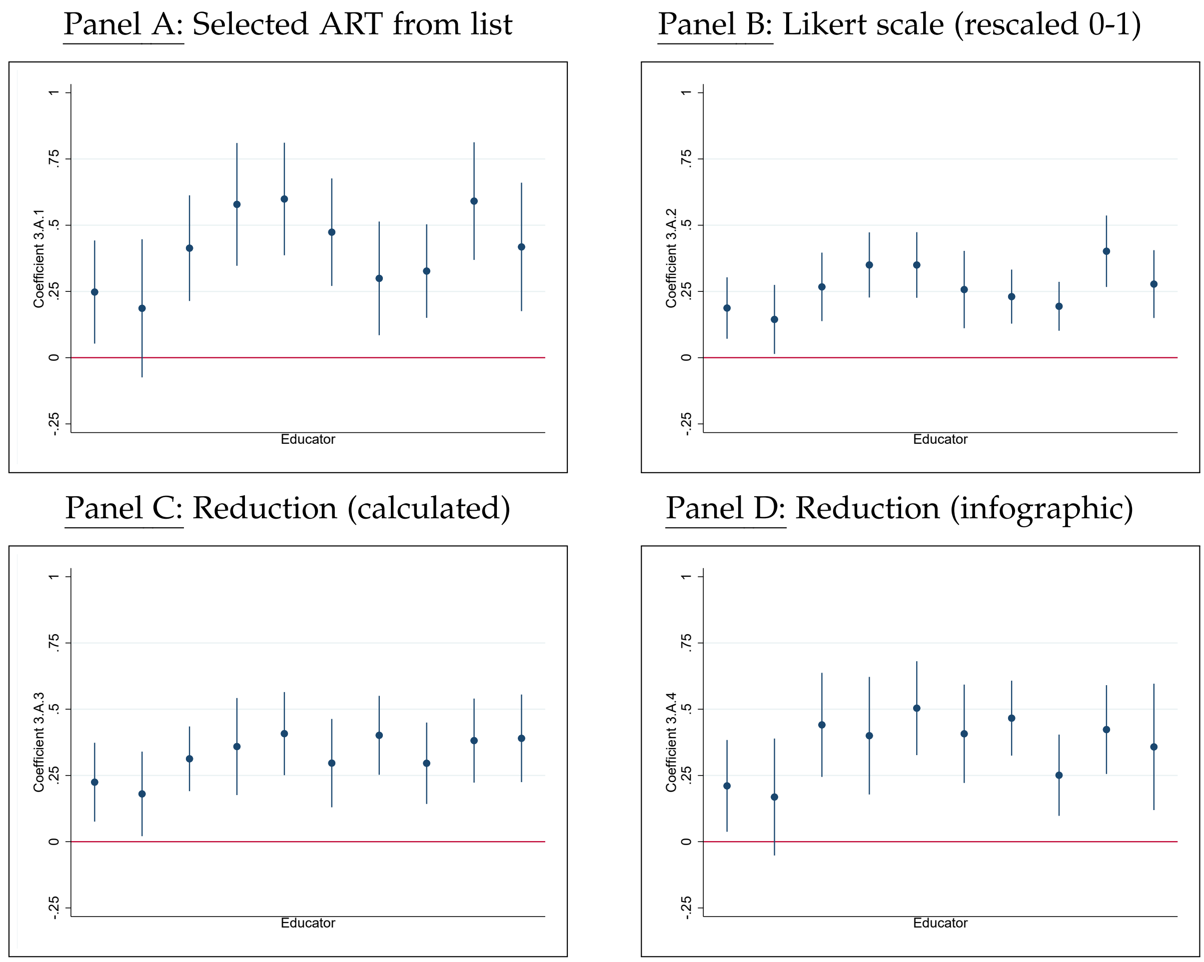
Appendix

Figure A1: Study Area



Note: The study included 122 villages in Zomba District, Malawi, represented by blue dots. Administrative data was obtained from 18 clinics, represented by red squares.

Figure A2: Variation in Beliefs Coefficients by Educator



Note: Coefficients analogous to Columns (1) to (4) from Panel A of Table 3, interacting the intervention indicator with the indicator for the identity of the educator. Regressions include educator fixed effects.

Table A1: Intervention

Topic	Script	C	I
Initial beliefs (private benefits)	*Raise your hand if you believe that a person with HIV can live a long and healthy life with ART.*	X	
Private benefits	*A person who has HIV can live a long and healthy life, as long as he or she takes ART.*	X	X
Mechanism	*A person taking ART will still have HIV, but they will have a reduced viral load and few or no symptoms.*	X	X
Infographic C	Figure 1, Panel A	X	
Initial beliefs (externality)	*Imagine a couple. One person is HIV positive and the other is HIV negative. If the HIV-positive person takes ART, does that reduce the chance that the virus is passed to his or her partner? Raise your hand if you think the answer is yes.*		X
ART externality	*If a person with HIV takes ART, it will greatly reduce the chance of spreading HIV. Imagine an area where no one takes ART, where 100 people contracted HIV last year. If all of their partners had been taking ART, only 4 people would have contracted HIV.* *An HIV-positive person taking ART is 96 percent less contagious. This is true for both men and women. ART reduces the amount of virus in the body, which reduces the chance that the virus will be transmitted from one person to another.*		X
Infographic I	Figure 1, Panel A		X
Other information about ART	*Only HIV-positive people should take ART, and should adhere properly. If he or she forgets to take the pills, his or her viral load will increase.*	X	X
Prevention	*For maximum protection, you should practice faithfulness and use condoms.*	X	X
Availability	*Health clinics offer free HIV testing and ART.*	X	X
Questions	*For other questions, ask at the health clinic.*	X	X

Note: C = Control arm, I = Intervention arm.

Table A2: Percent Tested for HIV per Month Post-Intervention (Table with Covariate Estimates)

	(1) All	(2) Men	(3) Women	(4) High risk	(5) Sexually active	(6) Pregnant
Intervention	0.188**	0.191*	0.174*	0.194*	0.238**	-1.064
	(0.083)	(0.108)	(0.101)	(0.101)	(0.107)	(1.876)
Km to nearest clinic	-0.079***	-0.068**	-0.092***	-0.044**	-0.069***	0.021
	(0.023)	(0.032)	(0.024)	(0.021)	(0.022)	(0.476)
% tested pre-intervention	0.549**	0.667*	0.420**	0.199	0.187	8.127**
	(0.265)	(0.379)	(0.174)	(0.163)	(0.173)	(3.769)
% men tested pre-intervention	0.076	0.057	0.090	0.132	0.299	-4.627
	(0.150)	(0.184)	(0.154)	(0.216)	(0.235)	(3.004)
% on ART pre-intervention	0.018	0.002	0.036	0.017	0.026	1.635***
	(0.025)	(0.027)	(0.027)	(0.016)	(0.020)	(0.315)
Village target population	-0.002*	-0.001	-0.002**	-0.000	-0.001	-0.034**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.014)
Meeting attendance	0.001	-0.001	0.003	-0.001	-0.000	0.030
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.027)
Mean y in control	0.58%	0.49%	0.68%	0.39%	0.62%	14.1%
Proportional increase	32%	39%	25%	50%	38%	-8%
Obs (Village-months)	366	366	366	366	366	366

Note: Administrative data from 18 clinics. Dependent variable: percent (/100) of village population (Malawi National Statistics Office census) tested for HIV post-intervention. (1)-(3): reproductive age population as defined by 2015-16 Malawi DHS (non-pregnant women aged 15-49, men aged 15-54). (4): high-risk population includes 5-year age groups with >10% HIV prevalence based on 2015-16 Malawi DHS (non-pregnant women aged 30-49, men aged 35-54). (5): sexually active population includes 5-year age groups such that median 2015-16 Malawi DHS respondent reported sexual activity in the past week (non-pregnant women aged 20-44, men aged 25-54). (6): pregnant population. Regression is OLS at the village-month level (3 months), with month fixed effects, indicators for stratification bins, and a constant. Heteroskedasticity-robust standard errors clustered at the village level, in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A3: Percent Tested for HIV per Month Post-Intervention (Weighted Least Squares)

	(1) All	(2) Men	(3) Women	(4) High risk	(5) Sexually active	(6) Pregnant
Panel A: Pooled results (3 months)						
Intervention	0.166**	0.152*	0.175**	0.164**	0.209**	0.125
	(0.072)	(0.088)	(0.087)	(0.076)	(0.084)	(1.670)
Mean y in control	0.58%	0.49%	0.68%	0.39%	0.62%	14.1%
Proportional increase	29%	31%	26%	42%	34%	1%
Obs (Village-months)	366	366	366	366	366	366
Panel B: Impact by month post-intervention						
Experiment period	-0.027	-0.197	0.137	-0.079	0.030	4.153
	(0.157)	(0.165)	(0.238)	(0.164)	(0.192)	(3.102)
1 month post-intervention	0.276**	0.317**	0.212	0.123	0.306**	-0.384
	(0.129)	(0.150)	(0.163)	(0.113)	(0.138)	(2.517)
2 months post-intervention	0.005	0.090	-0.085	0.081	0.033	-0.560
	(0.144)	(0.138)	(0.216)	(0.129)	(0.197)	(3.426)
3 months post-intervention	0.310**	0.163	0.470***	0.352**	0.459***	0.362
	(0.122)	(0.145)	(0.162)	(0.164)	(0.147)	(2.659)
Mean y in control, month 1	0.37%	0.29%	0.45%	0.3%	0.37%	11.7%
Proportional increase, month 1	75%	110%	47%	42%	83%	-3%
Village-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs (Village-months)	488	488	488	488	488	488

Note: Administrative data from 18 clinics. Dependent variable: percent (/100) of village population (Malawi National Statistics Office census) tested for HIV post-intervention. (1)-(3): reproductive age population as defined by 2015-16 Malawi DHS (non-pregnant women aged 15-49, men aged 15-54). (4): high-risk population includes 5-year age groups with >10% HIV prevalence based on 2015-16 Malawi DHS (non-pregnant women aged 30-49, men aged 35-54). (5): sexually active population includes 5-year age groups such that median 2015-16 Malawi DHS respondent reported sexual activity in the past week (non-pregnant women aged 20-44, men aged 25-54). (6): pregnant population. The experiment period is 25 days, and the post-intervention periods are each one month. Panel A does not include the intervention period. In Panel B, reported coefficients are for the intervention interacted with time period. Regression is weighted least squares (weighted by village population) at the village-month level, with village-level covariates listed in Table 1, Panel A, time period fixed effects, indicators for stratification bins, and a constant. Heteroskedasticity-robust standard errors clustered at the village level, in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A4: Sexual Activity

	(1) Sexual intercourse	(2) Condoms used	(3) Pregnancy
Intervention	0.589*	0.012	0.018
	(0.305)	(0.111)	(0.013)
Mean y in control	1.58	0.34	0.04
Obs (Individuals)	1330	1325	1343

Note: Survey to meeting attendees approximately 4 months post-intervention. (1) Number of acts of sexual intercourse, recalled over the past 7 days. (2) Number of condoms used, recalled over the past 7 days. (3) Self or partner is pregnant. OLS with a constant and all covariates from Table 1, indicators for stratification bins. Heteroskedasticity-robust standard errors clustered at village level, in parentheses. * p<0.10, ** p<0.05, *** p<0.01.