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# Perceived efficacy of HIV treatment-as-prevention among university students in Johannesburg, South Africa

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## ABSTRACT

**Objective** Antiretroviral therapy (ART) nearly eliminates HIV transmission. Yet information on treatment as prevention (TasP) has been slow to diffuse in sub-Saharan Africa. We assessed TasP knowledge among university students in South Africa.

**Methods** We conducted a cross-sectional survey of first-year university students at a large public university in Johannesburg, South Africa, all of whom would have recently completed secondary school HIV curricula. Respondents were asked to consider the likelihood of HIV transmission in a serodiscordant couple having condomless sex with and without virally suppressive ART. Beliefs were elicited using a 0–20 visual scale. Perceived TasP efficacy was computed as the relative reduction in risk associated with virally suppressive ART. We compared beliefs with estimates from the scientific literature and assessed associations with demographics, HIV testing history and qualitative measures of HIV knowledge and risk perception.

**Results** The analysis included 365 university students ages 18–25 years (48% female, 56% from Gauteng Province). On average, perceived annual risk of HIV transmission with virally suppressive ART was 73%; the objective risk is <1%. On average, respondents perceived that virally suppressive ART reduced annual transmission risk by 17%; the objective reduction in risk is >96%. We observed no differences in perceived TasP efficacy by participant characteristics and testing history. Perceived TasP efficacy was correlated with the (correct) belief that HIV risk increases with sexual frequency.

**Conclusions** University students in South Africa underestimated the prevention benefits of HIV treatment. Low knowledge of TasP could limit demand for HIV testing and treatment among young adults.

## INTRODUCTION

The HIV Prevention Trials Network (HPTN)-052 trial<sup>1,2</sup> and multiple large cohort studies<sup>3,4</sup> showed that antiretroviral therapy (ART) eliminates HIV transmission if the infected partner is virally suppressed. Treatment as prevention (TasP) has motivated countries to expand ART coverage in order to reduce HIV incidence.<sup>5</sup> However, there remain significant gaps in HIV testing and treatment, particularly among young adults.<sup>6–8</sup>

Despite scientific consensus on the efficacy of TasP, little is known about the diffusion of TasP information to young adults in countries where

HIV is endemic. Studies have found increases in TasP knowledge in the 2010s among male sexual minority populations in North America, Europe and Australia.<sup>9–12</sup> However, data from sub-Saharan Africa are scarce.<sup>13</sup> Evidence from South Africa, Zambia and Uganda suggest low familiarity with TasP in rural areas.<sup>14–16</sup> However, information may have diffused faster in urban areas, among young adults, and among those with access to secondary-school HIV education and university health services.

We set out to measure beliefs about TasP among first-year university students in Johannesburg, South Africa. All South African university students would have received HIV education throughout their primary and secondary schooling, as South Africa has provided HIV education under the Integrated School Health Programme since 2000.<sup>17</sup> We elicited participants' beliefs about the probability of HIV transmission in a serodiscordant couple, varying whether the HIV-infected partner was on ART and virally suppressed. We computed TasP efficacy as the perceived reduction transmission risk with ART. We assessed the association of perceived TasP efficacy with respondent characteristics and beliefs.

## METHODS

### Procedures

We surveyed first-year students, aged 18–25 years, between August and October 2017 at a large, public university in Johannesburg, South Africa.<sup>17</sup> Students in common areas of university campus (eg, library, canteen and lunch area) were invited to participate. We excluded students who had completed secondary school more than 3 years ago, those who had been a university student for more than 1 year and those who were not comfortable communicating in English. After providing written informed consent, study participants completed a self-administered, paper-based questionnaire. This study was nested as part of a larger study, the HIV/TB Knowledge, Risk Perceptions and Barriers to Accessing Care study.<sup>17</sup>

### Measures

We assessed beliefs about the likelihood of HIV transmission in four scenarios using a Visual Analogue Scale (online supplemental table 1).<sup>12</sup> Participants were asked: 'Consider a woman who does not have HIV. Imagine she has sex one time



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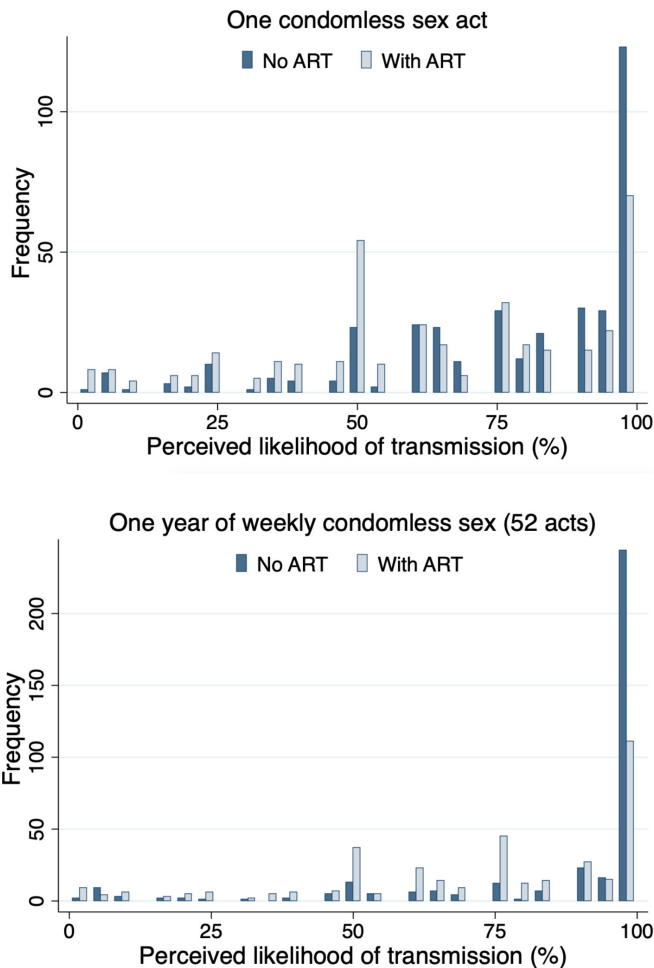
with a man who is HIV-infected and they do not use a condom. Choose a number from 0 to 20 to reflect how likely you think it is that she will become infected with HIV'. Participants were also asked to consider the likelihood after a year of weekly condomless sex (52 times). We then asked participants to consider the likelihood of HIV transmission (after 1 and 52 sex acts) in an alternate scenario 'with a man who is HIV-infected but who is taking ARVs every day and is virally suppressed'. We transformed all responses to a 0%–100% scale, multiplying by 5. We defined perceived efficacy of TasP as the relative (percent reduction in transmission risk due to virally suppressive ART after 52 condomless sex acts.

The four transmission scenarios were chosen to reflect realistic situations that we could benchmark to the scientific literature. In a meta-analysis of studies from low-income countries, the per-act HIV transmission probability from a man to a woman was estimated to be 0.3%.<sup>18</sup> After 52 condomless sex acts, the probability of HIV acquisition is 14.5%, computed as  $1 - (1 - 0.003)^{52}$ . The HPTN-052 trial found a 96% reduction in infection risk,<sup>19</sup> implying a 0.01% risk after 1 sex act and a 0.6% risk of HIV acquisition after 52 condomless sex acts with a partner on ART and virally suppressed. The PARTNERS and Opposites Attract studies indicate the true transmission risk when virally suppressed is zero (or very close to zero).<sup>3,4</sup>

Data were additionally collected on respondents' age, gender, location of secondary school, receipt of financial aid, residence in student housing, source of health insurance, food insecurity, and an asset index.<sup>20</sup> Participants were asked when they last had an HIV test. HIV knowledge was assessed using an index of 42 items,<sup>11</sup> split at the median into high and low knowledge. HIV risk perception was assessed using an abridged version of the Napper Scale (online supplemental table 2),<sup>21</sup> split at the median into low-risk and high-risk perception. Finally, we collected data on beliefs related to the effect of sexual frequency and ART on transmission (online supplemental table 3). Details on all measures are described elsewhere.<sup>17</sup>

## Data analysis

We plotted the distributions of perceived likelihood of HIV transmission in the different scenarios and we computed the mean and 10th, 25th, 50th, 75th and 90th percentiles of these distributions. We assessed absolute differences in perceived transmission risk associated with frequency of sex acts (1 condomless sex act vs 52 condomless sex acts) and with virally suppressive ART (52 condomless sex acts vs 52 condomless sex acts on ART). We summarised perceived TasP efficacy in two ways. First, we computed the *population-average* perceived TasP efficacy:  $100\% - 100\% \times (\text{average perceived 1-year transmission risk with ART} / \text{average perceived 1-year transmission risk without ART})$ . This quantity is most comparable to the HPTN-052 trial, which reported the ratio of infection rates in treated and control groups. Second, we computed *individual-level* perceived TasP efficacy as the percent reduction in perceived transmission risk with ART for each respondent. Some participants reported higher transmission likelihood with ART, compared with without ART; these responses were bottom-coded at 0% prevention efficacy of TasP. We plotted the distribution of individual-level perceived TasP efficacy as a histogram and assessed differences in perceived TasP efficacy by respondent characteristics and beliefs. Stata/SE V14.2 was used for all analyses. (online supplemental files 2, 3)



**Figure 1** Perceived likelihood of HIV transmission in four scenarios. Note: n=365. The distribution of beliefs about the likelihood that a woman would become infected with HIV is shown if she had condomless sex with an HIV-infected male partner in four scenarios: (top) one sex act with versus without virally suppressive ART and (bottom) 52 sex acts with versus without virally suppressive ART. ART, antiretroviral therapy.

## RESULTS

### Respondent characteristics

A total of 365 students were included in the analysis. The sample was 48% female; 45% were ages 18–19 years (53% were 20–25 years); and 44% attended secondary school outside of Gauteng Province. Just over half of respondents reported receiving a loan or scholarship to fund their tuition, and about half lived on campus in student housing (online supplemental table 3). The sample was 96% black African.

### Transmission risk in 1 vs 52 sex acts

Respondents believed HIV transmission to be much more likely than reported in the scientific literature. **Figure 1** shows the distributions of participants' transmission beliefs in the four scenarios. On average, respondents perceived a 78.3% likelihood of transmission after one condomless sex act in a serodiscordant couple, and a 87.9% likelihood of transmission after 52 sex acts, compared with objective risks of 0.3% and 14.5% (table 1). Many respondents perceived similar risks from 1 and 52 sex acts. These belief patterns are consistent with responses to survey questions: 95.9% of respondents affirmed that someone

**Table 1** Perceived versus objective transmission risk under four scenarios

Parameter	Objective	Perceived					
		(mean)	10th	25th	50th	75th	90th
Risk of HIV transmission (%)							
Scenario 1: one sex act	0.30	78.3	45	65	85	100	100
Scenario 2: one sex act with ART	0.01	65.1	25	50	65	95	100
Scenario 3: 52 sex acts	14.5	87.9	50	90	100	100	100
Scenario 4: 52 sex acts with ART	0.62	73.1	35	55	75	100	100
Efficacy of TasP							
Population average	96%	16.8%					
Individual-specific		20.3%	0%	0%	10%	33%	50%

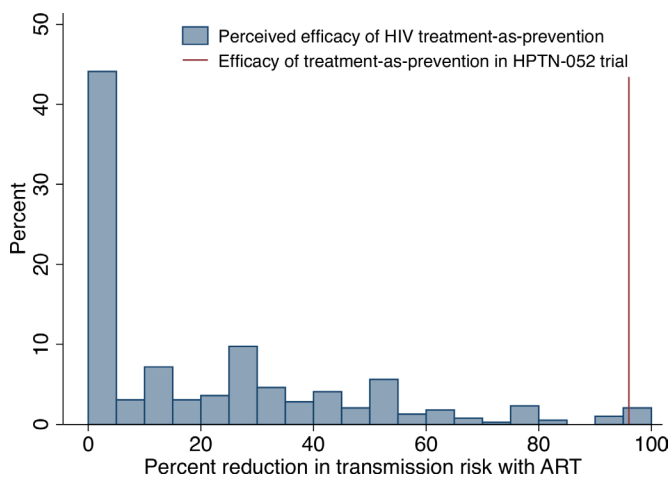
Note: n=365. Table displays mean perceived transmission risk across the four scenarios in the study sample. Transmission risks are probabilities expressed as percentages. Efficacy of TasP is computed as the relative (percent) reduction in transmission risk associated with ART. Objective risks are computed based on a uniform 0.3% per-act transmission risk<sup>18</sup> and a 96% relative reduction in per-act transmission with ART.<sup>1</sup> ART, antiretroviral therapy; TasP, treatment as prevention.

can get HIV by having sex one time. Yet only 55.3% agreed that having sexual intercourse less frequently reduced your risk of getting HIV (online supplemental table 3).

### Transmission risk with virally suppressive ART

Participants perceived lower risk of transmission when the HIV-infected partner was on virally suppressive ART (figure 1); however, perceived risk remained high. Over three-quarters (77%) of respondents perceived a 50% or greater likelihood of contracting HIV after just 1 sex act with a person with HIV who was on ART and virally-suppressed. The average perceived risk of transmission was 65.1% in 1 sex act and 73.1% in 52 sex acts when the HIV-positive partner was on ART and virally suppressed. The objective risk in these scenarios is zero (or very close to zero). The population-average perceived efficacy of TasP was 16.8%, compared with the 96% reported in the HPTN-052 trial (table 1).

Figure 2 shows the distribution of individuals' beliefs about TasP efficacy on a relative scale (for risk differences, see online



**Figure 2** Perceived efficacy of HIV TasP. Note: Histogram displays the distribution of subject-specific beliefs about the prevention efficacy of ART, that is, the relative reduction in transmission risk with virally suppressive ART after 1 year of weekly condomless sex (52 times). Perceived TasP efficacy is defined as  $100\% - 100\% \times (\text{perceived transmission risk with ART} / \text{perceived transmission risk without ART})$ . 0% reduction in risk includes respondents who reported higher transmission with ART than without ART. ART, antiretroviral therapy; TasP, treatment as prevention.

supplemental figure 1). Two respondents reported zero risk of transmission without ART and thus TasP efficacy was not defined; they are excluded from the reported results. Of 363 respondents, 160 (44.1%) did not report lower perceived transmission risk if the HIV-infected partner was on ART and virally suppressed. The median respondent perceived a 10% reduction in transmission risk with ART (table 1). Just 16.3% (59/363) believed there was a 50% or greater reduction in transmission risk with virally suppressive ART, and just 2.8% (10/363) of respondents believed that there was a 96% or greater reduction in risk.

Beliefs about TasP efficacy did not vary by demographic characteristics, socioeconomic status, HIV testing history nor HIV knowledge (online supplemental table 3). There was a modest and marginally significant increase in perceived efficacy among respondents who agreed with the statement: 'ART reduces transmission risk' ( $p=0.075$ ). Higher perceived TasP efficacy was associated with lower perceived HIV risk ( $p=0.016$ ). Higher perceived TasP efficacy was also associated with the belief that having less risk reduces infection risk ( $p<0.001$ ), suggesting that an orientation towards a biological understanding of transmission may be important for people to assimilate information on TasP into their beliefs.

### DISCUSSION

Nearly a decade after HPTN-052 showed that HIV treatment prevents transmission of the virus, young adults in South Africa remain largely unaware of these benefits. Although all South African university students would have received HIV education throughout their primary and secondary schooling, we found beliefs about HIV transmission that differed markedly from the scientific literature. We found that (1) respondents overestimated the probability of HIV transmission; (2) respondents underestimated the efficacy of HIV TasP; and (3) as a result, respondents vastly overestimated the likelihood of transmission when on ART and virally suppressed. The perceived annual risk of transmission with ART was 73%. The objective risk is less than 1%. As one respondent wrote, 'Taking ARVs doesn't matter. As long you are infected, it is very likely [for your partner] to get infected'.

Misperceptions about transmission risks are perhaps unsurprising. Historically, HIV education campaigns have exaggerated the virulence of HIV,<sup>22</sup> emphasising that you can get HIV from just one condomless sex act. Emphasis on this message may have contributed to the widespread belief<sup>23</sup> that HIV transmission

in one sex act is not just *possible* but *likely*. In many countries including South Africa, the prevention benefits of ART are not widely emphasised in public health messaging, school-based HIV curricula, nor HIV counselling.<sup>24</sup> Although stable serodiscordant couples in HIV care are increasingly counselled on TasP, this represents a small fraction of young adults at risk. Consistent with the lack of emphasis on TasP in clinical settings, we found no differences in TasP knowledge by recent use of HIV testing nor by gender (despite gender disparities in care-seeking). Younger participants who were more recently in secondary school had marginally higher TasP knowledge than older participants, but the difference was not statistically significant.

Misperceptions may have significant impact on behaviour. Overestimating transmission may lead to fatalism<sup>25</sup> and may contribute to greater HIV stigma and lower testing.<sup>26</sup> Underestimating TasP efficacy could reduce the perceived benefits of treatment, particularly among people entering HIV care early in infection.<sup>27</sup> Studies from the USA indicate that integrating TasP education into HIV counselling can improve adherence.<sup>28</sup> In a cluster-randomised trial in Malawi, providing communities with information on TasP reduced stigma and increased HIV testing.<sup>29</sup> A study in South Africa found that providing information on TasP increased HIV testing among men.<sup>30</sup> Although there are reasons to be cautious in messaging on TasP, for example, potential for spread of other sexually-transmitted infections if people reduce condom use, providing information on the low risk of transmission on ART has potential to increase perceived benefits of ART, leading to greater treatment uptake, lower population viraemia, and fewer new HIV infections.<sup>31</sup>

Our analysis has some limitations. First, the study was a voluntary response sample. Although quite diverse in terms of demographic and socioeconomic characteristics, the sample was not designed to be representative of all students at the university, nor of all university students in South Africa. Second, it is possible that respondents may have interpreted the transmission probability questions in a qualitative way, reporting general feelings about the likelihood of an event rather than beliefs about the statistical probability of it occurring. Nevertheless, these data offer a more fine-grained picture of transmission beliefs than previously reported for this population.

A recent systematic review found that 31 studies measured TasP knowledge globally, from 2008 to 2020.<sup>13</sup> However, just

two were quantitative studies of community-based samples in sub-Saharan Africa. In 2013, 65% of survey participants in rural Malawi perceived that ART had no impact on transmission risk.<sup>29</sup> In 2017, young adults in rural South Africa perceived a 75% annual risk of HIV transmission in a mixed status couple using TasP, similar to the findings in this study.<sup>32</sup> Our study participants were urban university students who had all recently completed the secondary school curriculum in South Africa—a population one might expect to have high access to health information. To our knowledge, this the first study on TasP knowledge in an urban African setting.

In South Africa, young adults are at high risk of HIV infection and have among the lowest rates of engagement with HIV care.<sup>7</sup> Addressing knowledge gaps regarding the prevention benefits of treatment through campaigns such as Undetectable=Untransmittable (U=U) could encourage greater HIV testing and care-seeking in this population. Educational institutions offer valuable opportunities to provide accurate information to young adults about the benefits and limitations of TasP and to reduce stigma associated with HIV treatment.

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**Contributors** JB and DE jointly conceptualised the study. DE designed and oversaw the study procedures. JB designed the survey instruments and analysis plan with input from DO. NM oversaw data collection and management. DE, JB, and NM wrote the first draft. All authors contributed to critically revising the paper, gave final approval of the version to be published and agreed to be accountable for all aspects of the work. JB is the study's guarantor.

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**Data availability statement** All data relevant to the study are included in the article or uploaded as supplementary information. Stata data and .do file are available as supplementary information for replication purposes.

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## Key messages

- ▶ HIV treatment prevents onward transmission of the virus; however, it is unknown whether information about HIV treatment-as-prevention has diffused to young adults in South Africa.
- ▶ We conducted a cross-sectional survey of first-year university students to determine beliefs about HIV transmission with and without virally suppressive HIV treatment.
- ▶ Respondents perceived a 73% annual transmission risk in a serodiscordant couple even if the HIV-infected partner was virally suppressed; the true risk is <1%.
- ▶ Respondents perceived that HIV treatment reduced transmission by 17% on average, much lower than the 96% efficacy demonstrated in the HIV Prevention Trials Network-052 trial.
- ▶ Gaps in knowledge about HIV treatment-as-prevention may contribute to suboptimal care-seeking and persistent HIV stigma among young adults.

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