IT TAKES TWO: THE DYADIC AND GENDERED CONTEXT

OF HIV TESTING, RISK ASSESSMENT, AND PARTNER COMMUNICATION

IN KISARAWE, TANZANIA

by
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Abstract

Background: Sexual transmission of HIV takes place between two people, yet dyads are rarely the focus of HIV-related interventions. Given the increasing importance of HIV testing, understanding how dyads influence each other's motivations for HIV testing and what drives partner communication could help create effective interventions that leverage partner testing. This dissertation seeks to understand the dyadic and gendered context of partner communication and sexual risk in influencing decisions surrounding HIV testing in Kisarawe, Tanzania.

Methods: Manuscript 1 examines factors associated with prior HIV testing, stratified by gender, to better understand what drives HIV testing behavior using Social Action Theory. Manuscript 2 uses Categorization and Regression Tree analysis (CaRT) to create risk assessment tools for men and women to use during testing so that high-risk individuals can be identified and encouraged to discuss HIV testing with their sexual partners. Given the emphasis on partner communication as the referral mechanism discussed in Manuscript 2, Manuscript 3 explores factors related to partner communication about HIV using the Theory of Gender and Power.

Results: Correlates of HIV testing, partner communication, and HIV-related risk differed by gender across analyses. HIV testing rates were lower for men and young people. Having had prior conversations about HIV was positively correlated with prior testing among men. At the dyadic level, knowing if a sexual partner had tested for HIV was associated with recent testing among men. As a means to foster partner referral for HIV

testing, we developed a 6- and 10-item risk assessment questionnaire for men and women, respectively, to classify individuals at heightened risk of infection using simple behavioral predictors. Regarding factors related to partner communication, both men and women had higher odds of communication if they had more progressive gender norms, more favorable social norms toward HIV prevention, and were socially engaged.

Conclusions: Our findings help understand the specific pathways through which gender norms and social-level factors influence dyadic behavior in relation to HIV testing and partner communication. Gender-specific, proactive interventions are needed to increase testing uptake, especially for young people and men. Interventions that encourage sexual partners to test could facilitate uptake of HIV testing services but would require increased partner communication. Drivers of partner communication are inherently socially and structurally-based. Creating change will require interventions at multiple levels—from interventions to improve individual and dyadic-level communication and negotiation skills to interventions at the social-level to increase community dialogue.

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INTRODUCTION

Background

Current state of HIV prevention

Since the beginning of the HIV epidemic, over 78 million people have been infected, resulting in an estimated 39 million deaths[1]. Today about 35 million people are living with HIV, with the majority of these people residing in sub-Saharan Africa [2]. Despite being an infectious disease with a well-defined route of transmission, efforts to halt the epidemic have been largely behaviorally-based as no cure exists and widespread treatment was not readily available until relatively recently (and access remains limited). Initial responses to the epidemic focused on individual-level behavior change, e.g., increasing condom use and decreasing number of sexual partners, which have been mostly ineffective as standalone interventions in generating significant reductions in HIV incidence. More recently researchers, policy-makers, and program planners have focused on understanding and intervening upon social and structural drivers such as poverty, gender dynamics, and social inequality that play a critical role in shaping behavior and HIV-related risk environments[3, 4].

However, recent biomedical advances, such as using treatment as prevention[5], voluntary medical male circumcision[6-8], and pre-exposure prophylaxis (PrEP)[9-12] have energized HIV prevention and shifted the prevention paradigm. These innovations sparked interest in "combination prevention" approaches that integrate biomedical, behavioral, and structural interventions into comprehensive HIV prevention packages[13].

These packages not only focus on increasing protective behaviors, such as condom use, but also on increasing uptake of biomedical interventions, such as initiating antiretroviral therapy (ART) if HIV-positive or circumcision or PrEP if HIV-negative, to prevent further spread of HIV.

In this new model of HIV prevention, HIV testing and counseling (HTC) plays an increasingly critical role as knowing one's serostatus is the gateway to accessing care and treatment for people who are living with HIV and can also serve as a means to behavior change in and of itself[14, 15]. Despite the wide-spread availability of HIV testing, rates of testing remain low globally. It is estimated that only 45% of people living with HIV are aware of their serostatus[2]; therefore, increasing testing rates has become a priority. At the 8th Conference on HIV Pathogenesis, Treatment, and Prevention in 2015, the World Health Organization released new HIV Testing Services Guidelines, which call for a massive expansion of HIV testing, especially for men, adolescents, and key populations[16]. Similarly, the first pillar of UNAIDS "90-90-90" goal is to test 90% of people living with HIV by 2020[17]. Given the importance of scaling-up testing, understanding why people are not testing and how to improve testing modalities remains a critical question for the field.

The intervention on which this dissertation is based is implementing a novel approach to HTC in Kisarawe, Tanzania by incentivizing HTC for individuals at higher risk of HIV infection and additional services for those who test HIV-positive, including further counseling and sexual partner referral. This dissertation seeks to understand what

factors are related to prior testing behavior for men and women, how individuals at higher risk for HIV infection can be quickly identified for targeted service delivery, and what influences partner communication about HIV-related risk.

The importance of dyads and gender in HIV prevention

One major challenge for HIV prevention is that HIV is predominantly transmitted through sex. Sex is intertwined with complex emotions, such as love and intimacy, and purposes, such as reproduction, pleasure, and economic gain. As Parker et al. state, "sex is a culturally informed experience, shaped by the inner world and material world in which humans live"[18]. At the center of this complexity is that sex involves two people with potentially different norms, beliefs, values, and sexual histories. Research has shown that taking protective measures against HIV, such as using condoms, can be perceived as mistrust between partners or as a tacit admission of infidelity, thus pitting love and trust against HIV prevention in relationships[19-21]. Similarly, conversations about HIV testing, especially among long-term stable couples, have been described as an "unusual event" signifying extraordinary circumstances, such as sickness or discovery of an extramarital affair, and not a matter of routine discussion[22]. These findings signify that dyadic-level interaction is critical in HIV prevention, yet this level is often overlooked in research and HIV-related interventions[23].

Compounding this complex picture is that among heterosexual couples, gender roles and norms dictate how men and women interact in sexual relationships. Unequal, gendered power dynamics affect HIV-related risk for both men and women. In addition

to being more at-risk for HIV infection due to biological reasons[24], research from sub-Saharan Africa shows that women's subordinate economic and social position also place them at higher risk[25-27]. Women have less power to negotiate in sexual relationships as sexual-decision making is male-dominated[28], have less access to education and resources[29], and often face physical and sexual violence[25, 30]. Men, conversely, adhere to dominate, or "hegemonic" masculinities as termed by Connell[31], which refer to "patterns of practices" that assert men's power over women. As related to HIV risk, hegemonic masculinities manifest themselves through high-risk sexual behavior, including having multiple sex partners, not using condoms, engaging in age-disparate relationships, intimate partner violence, alcohol abuse, and transactional sex[25, 30, 32, 33].

However, with regards to care-seeking, including accessing HIV testing and treatment, these same gender dynamics place men at a disadvantage as seeking help and playing the "sick role" are seen as weak and un-masculine[34-36]. As a result, men are more likely to delay initiating ART therapy, less likely to get tested for HIV, and in general have poorer HIV-related health outcomes as compared to women[37, 38]. Women, on the other hand, are more likely to be engaged with healthcare, most notably through accessing reproductive and antenatal services. The global scale-up of prevention of mother-to-child transmission (PMTCT) programs, which include routine HIV testing, has dramatically increased the number of women tested for HIV in sub-Saharan Africa[39]. Efforts have been made to involve male partners in these initiatives, but results have been mixed due to significant barriers and reluctance of men to test with their female partners[40, 41].

HIV testing and partner communication

Given the complex gender dynamics and unequal dyadic roles, reluctance of couples to test for HIV together is understandable, yet couples-based HIV testing and counseling (CHTC) has been promoted in sub-Saharan Africa[42], because it gives sexual partners the opportunity to discuss their HIV-related risks together, have disclosure of HIV status facilitated by a trained counselor, and develop a risk-reduction plan collectively[43]. Serial testing of sexual partners, as opposed to simultaneous testing during CHTC, remains an understudied phenomenon. Little is known about relationship dynamics and social and/or environmental factors that may lead one sexual partner to test for HIV and then convince his or her sexual partner to test at a later time. Serial testing allows individuals to test privately and communicate with partners about HIV on their own terms. The intervention on which this dissertation is based promotes an incentivized serial approach to HTC whereby one sexual partner can refer the other.

In order for the partner who received HTC to attract another partner to intervention services, the couple must have a discussion about HIV testing. Consequently it would be beneficial to know what influences partner communication about HIV, including characteristics of participants who do and do not discuss HIV risk with their partners. However, outside of disclosure of HIV status, little is known about what characteristics are associated with partner communication about HIV[44-46], despite research supporting the importance of communication in influencing protective behaviors, such as condom use[47]. Communication is a necessary part of HIV prevention

as exchanging information about HIV can lead to increased HIV awareness, including knowledge about modes of transmission, ways to prevent infection, and how to access prevention, care, and treatment resources. Given the importance of gender issues and dyadic interactions in HIV-related risk, understanding what drives partner communication about HIV is an understudied yet critical component of HIV prevention.

Dissertation Outline

This dissertation uses gender as a lens through which to explore factors related to prior HIV testing and partner communication, specifically looking at differences in motivation and behavior between men and women. A critical focus is on how dyadic-level factors, such as discussion about HIV between partners, affect HIV testing behavior, as well as how social- and structural-level variables affect dyadic-based communication about HIV. Additionally in this dissertation we create risk assessment tools for men and women that can be used during HIV testing and counseling to identify clients at higher risk of HIV infection. The goals of this identification process are twofold: 1) to provide high-risk clients access to additional services to help reduce their HIV-related risk, such as additional counseling, and 2) to provide an opportunity for clients to refer their sexual partners for testing by providing incentivized referral cards to give to sexual partners. The study in which this dissertation is based hypothesizes that such cards could serve as "conversation starters" for sexual partners to discuss HIV risk and/or testing. In sum, this dissertation examines the confluence of gender, communication, and sexual risk in influencing decisions surrounding HIV testing.

Manuscript 1 examines individual-, dyadic-, and social-level factors associated with prior HIV testing, stratified by gender, to better understand what drives HIV testing behavior in the study site. Manuscript 2 uses Categorization and Regression Tree analysis (CaRT) to create risk assessment tools for men and women to use during HTC so that high-risk individuals can be identified and encouraged to discuss HIV testing with their sexual partners. Given the emphasis on partner communication as the referral mechanism discussed in Manuscript 2, Manuscript 3 explores factors related to partner communication about HIV using the Theory of Gender and Power to elucidate who is communicating with their partners and who is not. Below we discuss the study setting and the theoretical underpinnings informing the dissertation.

Study Setting

HIV epidemic in Tanzania

Tanzania has 43 million inhabitants of whom an estimated 47% are under the age of 15[48]. The economy is mostly agrarian with 70% of the population residing in rural areas[48]. Tanzania remains one of the least developed countries in the world, with a Human Development Index ranking of 152 out of 187 countries, taking into account life expectancy, income, and educational attainment[49].

Tanzania has been experiencing a generalized HIV epidemic for over three decades. The first AIDS cases were diagnosed in the Kagera region in 1983, and by 1987 cases were reported in all regions of Tanzania[50]. Currently, Tanzania's estimated HIV

prevalence for adults aged 15-49 is 5.1%[51]. Although prevalence has decreased over the past decade, HIV remains one of the most significant health issues facing the country. Currently 62% of women and 47% of men in Tanzania report ever being tested for HIV and receiving their results as indicated in the 2011-2012 HIV/AIDS and Malaria Indicator Survey; however, rates remain relatively low given high knowledge of testing centers and a high testing coverage[51]. A study conducted in Northwest Tanzania found that the desire for HIV testing (31% among men and 24% among women) fell short of the percent of individuals actually completing testing (12% and 17% of men and women, respectively)[52]. This study also noted that women living in rural areas and those married and in monogamous relationships reported significantly less testing behavior than never married women residing in less rural areas[52]. Therefore, interventions targeting rural married women may be warranted, especially given evidence that being female and being married are significant predictors of HIV infection for rural Tanzanians[53].

This dissertation is based on an intervention in the district of Kisarawe, located in the Pwani (Coast) region of Tanzania, which has one of the lowest per capita incomes in Tanzania[54]. The two areas of study—Masaki and Mzenga—make up 2 of the 15 administrative wards in the district[54]. Kisarawe contains one district hospital, 3 rural health centers, and 13 public dispensaries[54]. Masaki and Mzenga each contain one rural health center staffed by one or two medical officers, nurses, and casual daily workers[54]. As of 2012, the HIV prevalence in Pwani was 5.9% among adults aged 15-49, which is slightly above the national prevalence [51]. Like all regions of Tanzania, the health system in Kisarawe faces significant challenges such as a shortage of healthcare workers,

transportation difficulties to and from health centers, lack of staff supervision, and poor communication infrastructure[55]. Several ethnic groups comprise the population of Pwani region, but in Kisarawe the predominant group is the Zaramo. The Zaramo are a Bantu-speaking people from Eastern Tanzania who are predominantly Muslim, although many inhabitants practice traditional religion and healing practices[56].

Previous HIV research in Kisarawe

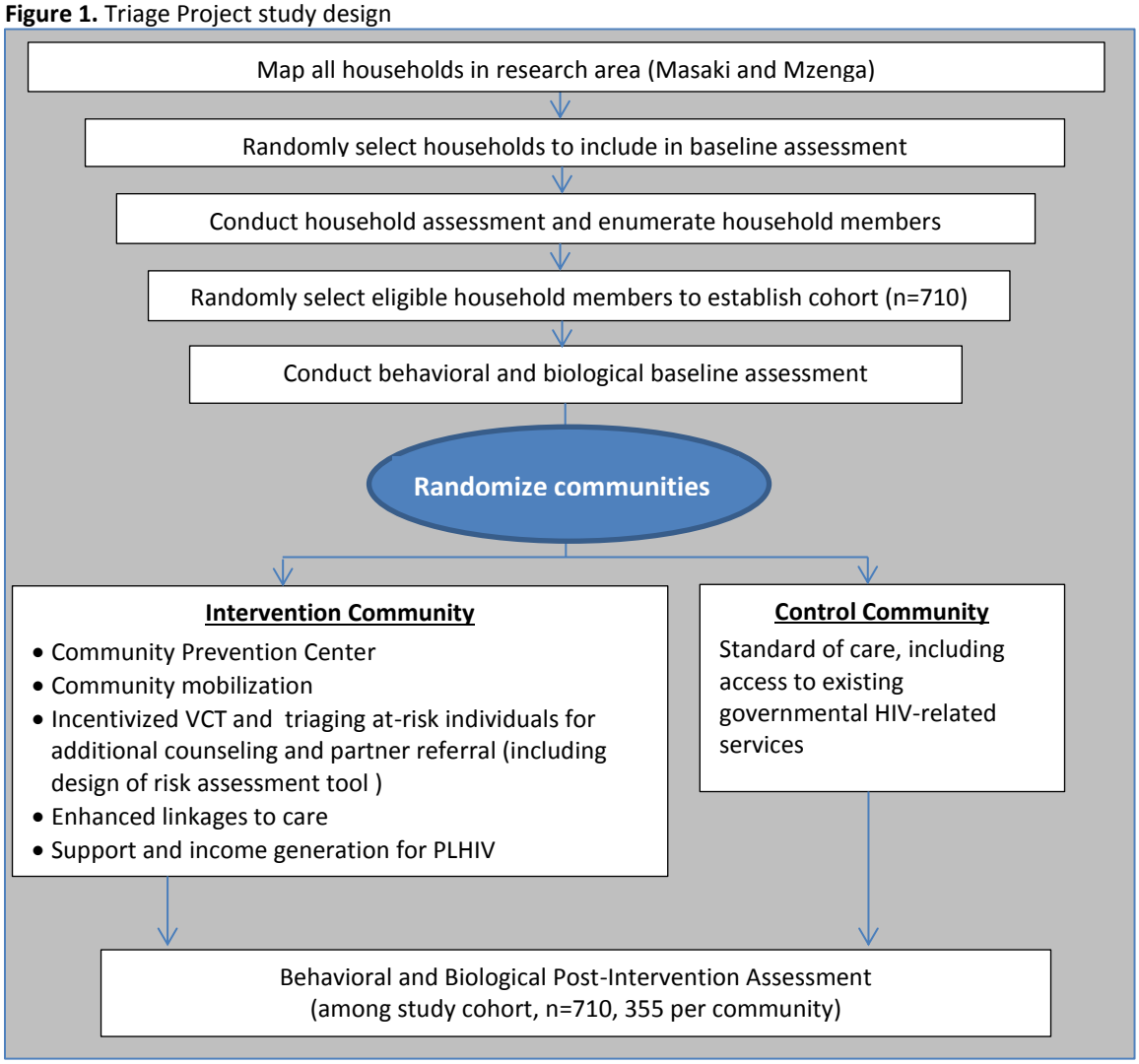
Ten communities in Kisarawe District participated in Project Accept, a multi-site randomized trial that assessed the efficacy of community mobilization, community-based mobile HTC, and post-support services on reducing HIV incidence. The trial spanned eight years. In Kisarawe, five communities served as intervention communities and the remaining five served as controls. The main trial results demonstrated a non-significant decrease in HIV incidence across study sites[57] and a significant increase in rates of HIV testing comparing intervention to control groups[58]. Across sites, the average difference in the proportion of community members receiving VCT comparing intervention to control communities was 40.2%, and community-based mobile VCT detected almost four times as many HIV cases as compared to standard VCT services[58]. In Kisarawe the estimated annual HIV incidence was estimated at 0.78% based on data collected during the post-intervention assessment of Project Accept among adults aged 16-32[59].

Triage Project

Based on findings from Project Accept, a combination HIV prevention pilot study is being undertaken in Kisarawe incorporating lessons learned from the previous

project. The new project, called the Comprehensive Triaged HIV Prevention Study (abbreviated as the Triage Project), is a community randomized trial located in two communities that served as controls during Project Accept. The two communities were chosen based on similarities in demographics, HIV-related risk behaviors, and geographic separation by a protected forest. The main objective of the study is to assess whether a combination HIV prevention intervention is effective in reducing STI incidence (HIV, syphilis, and Herpes simplex virus-2). During the post-intervention assessment in Project Accept, every household in the two communities was enumerated and mapped using GPS coordinates. For the Triage Study, a cohort of 710 participants aged 18-55 years (355 in each community) were chosen by randomly selecting enumerated households for inclusion, enumerating all members of the selected households, and randomly selecting one eligible participant for the cohort. The baseline assessment included a household survey measuring sociodemographic characteristics; an individual behavioral survey assessing sexual risk behaviors, prior HIV testing behaviors, and social and gender norms; and a biological assessment. The biological assessment included testing for HIV, syphilis, and HSV-2. The intervention implementation phase is currently ongoing and will last 18 months. Following the intervention, a post-intervention behavioral and biological assessment will take place among the 710 cohort members. The Triage Project study design is provided in Figure 1.

Figure 1. Triage Project study design



The intervention components are listed in Figure 1. In brief, the intervention will establish a community-based prevention center, staffed by local nurse counselors, community mobilizers, and adherence coordinators (for helping to coordinate care for clients who test HIV positive), where community members can go for free HTC, support services, and linkages to care. The HTC offered will be triaged, meaning individuals at higher risk for HIV infection or those who test positive will be offered additional

services. The additional services include receiving a small commodity-based incentive, such as a bar of soap or a bag of rice, for returning to the prevention center for an additional counseling session. Additionally, HIV-positive individuals and individuals at higher risk for HIV infection will be offered up to three referral cards to give to sexual partners. If the partners come in for HTC, they will also be given an incentive. The intervention also involves access to treatment adherence support for people living with HIV and group-based activities, including income generation projects and support groups.

Theoretical Foundations

This dissertation is based on the understanding that behavior and decisions about health have multiple spheres of influence, including social influence. The main theoretical underpinnings are presented below, moving from broad to narrow. First we present multi-level models that describe the complex, hierarchical levels which influence individual behavior. Then we move more specifically to a framework that focuses on the dyadic-level of influence and finally to a theory used to interpret gendered interactions within sexual dyads.

Social Ecological Model & Social Action Theory

The Social Ecological Model developed by McLeroy posits that behavior is shaped by factors at the intrapersonal, interpersonal, organizational, community, and policy levels[60]. It takes the "environment" used in the traditional epidemiological agent-host-environment model[61] and disaggregates it by the type of social environment

influencing health and behavior. Two main concepts derived from this model are that behavior spans multiple levels of influence and that behavior is shaped by and is shaped by the social environment, i.e. reciprocal causation, suggesting both behavior and aspects of the social world are dynamic and malleable. The Social Ecological Model has been adapted and built upon for disease-specific causes, including HIV. The Sweat-Denison Model outlines four levels of causation, the individual, environmental, structural, and superstructural levels relating to HIV and emphasizes the need to develop structural and environmental interventions to address fundamental causes[62].

One criticism of the Social Ecological Model is that it does not explain the *specific pathways* through which behavior is affected by the different levels of causation. The model is often drawn using concentric circles with the individual-level at the center and the other levels radiating out respectively. This limitation makes it difficult if not impossible to inform specific hypotheses about *how* behavior is influenced by multiple levels of factors.

Another model, the Social Action Theory (SAT), is a multi-level framework similar to the Social Ecological Model, but it uses principles from social psychology to build causal pathways between environmental factors, self-regulatory processes, and social interconnections to explain how different aspects of the social context influence behavior[63]. The model is complex and includes biological components, such as affect and arousal states, contextual factors, social connectedness, individual capabilities, motivational appraisals, encompassing norms, beliefs, and attitudes, to explain

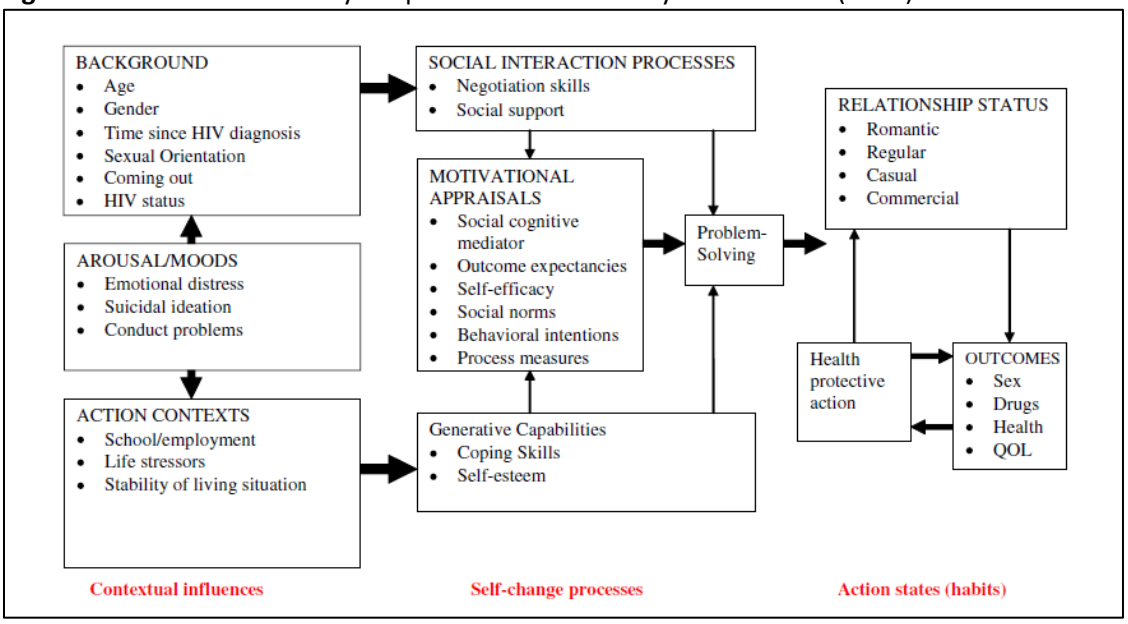
behavior. It expands on individual-level models, such as Social Cognitive Theory[64] and the Theory of Planned Behavior[65], which do include the influence of social norms on behavior, but fail to specify the mechanism through which the environment shapes social norms and behavior[66]. The SAT also emphasizes the importance of social relationships in creating and maintaining behavior change, which has important implications for examining partner communication related to HIV and uptake of HIV testing. As described by Ewart:

> "When behavior changes threaten to disrupt a valued relationship, a satisfactory outcome depends on the partners' ability to collaborate effectively in problem solving; that is, success depends on partners' conjoint (as opposed to individual) social capabilities."

This quote is highly relevant to conceptualizing sexual dyads and decisions they make regarding HIV prevention. The decision of whether or not to get an HIV test, and whether or not to involve a partner in this decision, depends in part on how much the partner thinks the action will disrupt the relationship.

Traube and colleagues have promoted the use of SAT in HIV prevention, both because it presents a broad platform, encompassing both individual-level and social-level factors, and because the specific pathways can be used to test hypotheses and model accuracy[66]. The adapted SAT model from Traube et al. is presented in Figure 2.

Figure 2. Social Action Theory adapted to HIV context by Traube et al. (2011)

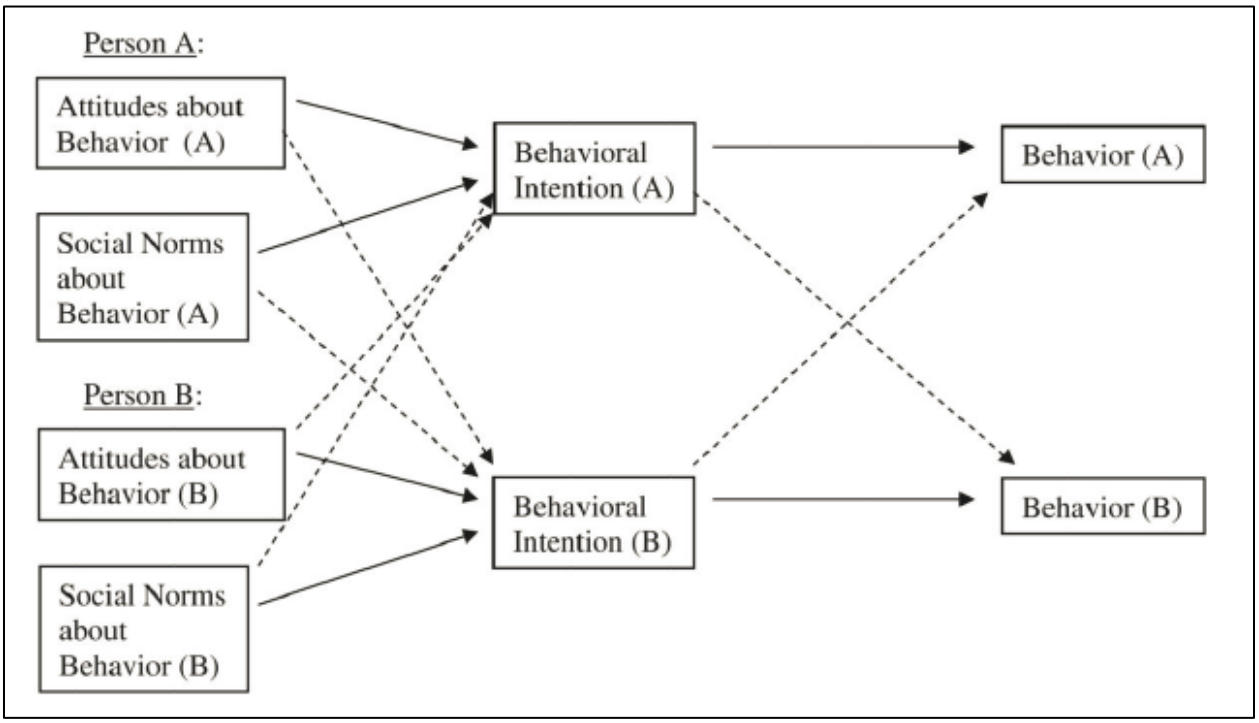


Framework for Incorporating Dyads in HIV Prevention

Focusing on the "social interaction process" piece of Social Action Theory, which also relates to the Interpersonal Level of the Social Ecological Model, a dyad represents the smallest form of social interaction possible. In HIV this interaction takes on heightened significance as HIV is spread through sexual dyads. Karney and colleagues developed a "Framework for incorporating dyads in models of HIV prevention" as a result of recognizing the crucial role dyads play in both HIV transmission and prevention[23]. This framework critiques individual-level models for not accounting for behavioral influence by relational partners, and presents (in Figure 3) how partner-influence can override a person's own norms and attitudes to enact behavior change. Despite being a dyadic-level framework, the model acknowledges that dyads are influenced by other levels of the Social Ecological Model as well, including individual level factors (e.g., education, gender), interpersonal factors (e.g., trust, commitment,

satisfaction, power, intimacy, and communication), and cultural factors (e.g., gender norms)[23].

Figure 3. Dyadic model from Karney et al.[23] showing partner-level influence for behavior change (dotted lines)



Theory of Gender and Power

As Karney and colleagues acknowledged in their dyadic framework, dyadic-level behavioral influence relies on other pieces of the Social Ecological Model, including structural-level constructs such as gender.

The Theory of Gender and Power has been used in Tanzania to assess women's risk of HIV infection[28]. Developed by Connell, the Theory of Gender and Power suggests that cultural and social differences between men and women are driven by three main dimensions: 1) sexual division of labor, 2) sexual division of power, and 3) cathexis, which is a term used to describe the social norms and expectations of men and

women[67]. As described by Wingood et al.[68], the sexual division of labor involves the different occupational spheres of men and women and the devaluation of occupations typically performed by women, including domestic housework and child rearing. Over time this leads to a gap in income and socio-economic status between men and women, which adversely impacts women through inhibiting education, employment, and marital options, thus lowering their socioeconomic status and affecting subsequent health-related outcomes, including HIV-related risk[68]. Additionally, the sexual division of labor can cause women to engage in sexual relationships at a young age or with an older sexual partner due to economic necessity[69, 70]. The sexual division of power reflects the capability of one individual or group of individuals to influence another, i.e., having power over others[68]. Operationally, the sexual division of power can be measured through exposure to gender-related violence, including intimate partner violence[30, 71]. Additionally, power imbalances can be manifested in behavioral risk factors, such as drug and alcohol use and having multiple sex partners, as these behaviors exhibit a lack of perceived control over behaviors or situations leading to unhealthy behaviors[68]. Cathexis involves the social expectations of women and men and how sexuality is attached to other social ideas, such as immorality[68]. Social norms related to women's passive role in sexual relationships can prevent her from using condoms or discussing HIV-related risk with her sexual partners. Additionally, exposure to and engagement in social groups may shape these norms and influence risk behavior[72].

Summary

For this dissertation, we hypothesize that partner communication about HIV will be influenced by constructs from the Theory of Gender and Power. We also hypothesize that if partners do communicate about HIV, such as by being provided a referral card during the intervention to give to their sexual partner, and using this card as a conversation starter, they could influence the action of their partner above and beyond what would have been expected given that person's own norms and beliefs. This is based on the dyadic framework from Karney and colleagues. Regarding why people would seek HIV testing in the first place, we use the Social Action Theory and the Social Ecological Model to inform an investigation into individual, dyadic, and social level factors influencing testing uptake.

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MANUSCRIPT 1:

THE GENDERED EXPERIENCE OF HIV TESTING: CONTEXTUAL, BEHAVIORAL, AND INTERPERSONAL CORRELATES OF PRIOR HIV TESTING AND RECENT HIV TESTING IN RURAL TANZANIA

Abstract

Background: The rapid expansion of antiretroviral treatment has provided a potential path for curtailing the HIV epidemic and prolonging lives in sub-Saharan Africa. However, receiving HIV testing remains the critical gateway to accessing treatment, but low uptake of HIV testing persists in sub-Saharan Africa, particularly for men. This study sought to understand reasons for HIV testing and factors related to prior HIV testing in Kisarawe Tanzania and differences that exist between genders using Social Action Theory.

Methods: We analyzed cross-sectional data from a random, population-based sample of men and women aged 18-55 years located in Kisarawe, Tanzania. Bivariate and multivariate logistic regression were used to identify the independent effects of contextual, behavioral, and interpersonal factors associated with any prior HIV testing and testing within the past year.

Results: In the sample of 644 participants, over 63% of men and 85% of women reported ever testing for HIV. Over half of female participants reported being tested as a result of pregnancy-related care. Young men and women (aged 18-25 years) had significantly lower odds of reporting prior HIV testing compared with older participants. Reasons for prior testing differed between men and women. For men, fear of testing was inversely associated with prior testing (adjusted odds ratio [aOR]=0.31 (95% confidence interval [CI]: 0.11-0.86, p=0.03). Having ever talked about HIV was positively associated with prior testing (aOR=2.28, 95% CI: 1.20-4.31, p=0.01). For women,

knowing someone who is living with HIV was associated with increased odds of prior testing (2.74, 95% CI: 1.24-6.07, p=0.01). Regarding recent testing, knowing if a sexual partner had received an HIV test was significantly associated with recent testing for men (aOR=2.96, 95% CI: 1.22-7.17, p=0.01), but not for women.

Conclusions: Women are being tested for HIV more than men in Tanzania as a result of receiving antenatal care. Dyadic communication about HIV testing is correlated with recent testing behavior among men. Reasons for testing differ by gender, which suggests the need for gender-specific, proactive interventions to increase testing, especially for young people and men. Interventions that encourage sexual partners to test, either together or serially, could facilitate uptake of HIV testing services, but care is needed to ensure interventions are rights-based and free from coercion, especially as gender and power dynamics impact partner communication.

Background

The increasing importance of biomedical interventions in HIV prevention has brought issues surrounding implementation, scale-up, and behavior change to the forefront. The first pillar of the "90-90-90" target established by UNAIDS is to test and diagnose 90% of all people living with HIV by 2020[1]. Testing remains the only pathway to knowing one's serostatus and accessing antiretroviral therapy (ART), which has both treatment and prevention benefits[2]. Despite UNAIDS targets, an estimated 19 million of the 35 million people living with HIV (54%) are unaware of their HIV status[3]. The second goal of the UNAIDS 90-90-90 plan is to initiate and sustain 90% of people living with HIV on lifelong ART, but this goal will never be achieved unless more people learn their serostatus.

In Tanzania, only 62% of women and 47% of men have ever taken an HIV test and received the results[4]. HIV testing in Tanzania is largely facility-based. Rural health centers often have a separate HIV-services building or room which provides HIV testing and counseling, as well as ART-related services. Since 2000 Tanzania has enacted provider-initiated testing and counseling (PITC) as part of prevention to mother to child transmission (PMTCT) programs, which routinely tests women for HIV during antenatal visits. Currently Tanzania reports testing 85% of pregnant women for HIV during antenatal care[5]. However, men are not reached as frequently with HIV testing services, and as a result, more women are tested than men. Efforts to increase male involvement

in PMTCT programs have often met with resistance from clients, low uptake, and identification of substantial barriers[6-8].

Gender inequities are a key driver of the HIV epidemic, as both biological factors and social factors place women at increased risk for HIV[9]. In Tanzania, traditional gender norms place women in a disadvantaged economic and social position[10], leading to exposure to violence[11], transactional sex[12], and lack of sexual-decision making power[13]. Exacerbating this risk are corresponding traditional ideas of hegemonic masculinities, which tie men's concept of being a "strong man" to sexual virility, dominance over women, and physical power[14]. However, these same masculine ideals put men at a disadvantage for receiving HIV testing and HIV-related care as they dissuade men from seeking help[15]. As a result men in general are less likely to test for HIV as compared to women[16], and men are less likely to be on ART compared to women [17]. In Tanzania, as in most of the world, men see clinics and hospitals as female domains where they feel uncomfortable and unwanted [6].

Factors related to HIV testing have been widely explored, but few studies use a gendered approach. Two quantitative studies from South Africa identified low testing rates among men and different motivations for testing between genders, with more women reporting testing due to non-voluntary reasons, such as antenatal care[18, 19]. Additionally, several qualitative studies have identified significant gender differences in testing behaviors across sub-Saharan Africa. A study from Uganda found that two competing ideas of masculinity, "reputation" and "respectability" greatly influence

men's willingness to test, with testing conflicting with expectations that men should be strong, resilient, and not in need of assistance[20]. Conversely, testing did align with men's motivation to be a family-focused provider and protector [20]. Another study from Lesotho found that men generally saw HIV testing as a service for women, not men, and that they could learn their HIV status "by proxy" by assuming they have the same serostatus as their female partners[21]. For women, studies suggest that rigid gender norms and scripts prevent women from being able to discuss HIV or HIV testing with their sexual partners as this could be seen as an admission of infidelity and could lead to violence or other negative consequences[21-23]. Other studies have found that men dominate sexual decision-making, including decisions surrounding HIV testing, and suggestions about HIV testing from women would undermine this authority[23, 24].

Given the growing importance of HIV testing within the HIV-care cascade, understanding gender differences in uptake of HIV testing between men and women could help inform programs and generate ideas for developing gender-specific or dyadic-based interventions to increase testing. This analysis sought to answer three questions about HIV testing uptake in Tanzania: 1) For what reasons do men and women test and not test for HIV, 2) What contextual, normative, and behavioral factors are related to any prior HIV testing, and 3) What recent risk behaviors and interpersonal factors are related to recent HIV testing?

Methods

Sampling methods and study population

This study used cross-sectional data collected in Kisarawe, Tanzania as part of the Triage Project, which is a phase II community-randomized trial assessing the effectiveness of a multi-pronged community-based HIV prevention intervention. The Triage Project is a follow-up study to Project Accept, a multi-site trial that assessed the effectiveness of community-based VCT, community mobilization/outreach, and post-test support services on reducing HIV infection and increasing HIIV testing rates[25, 26]. Kisarawe is a rural district in the Coast region of Tanzania located approximately 75 km southwest of Dar es Salaam. It is one of the most economically underdeveloped districts in Tanzania[27], and the region has the lowest HIV testing coverage in Tanzania[4]. Recent estimates suggest HIV prevalence in the region is 9.2% for women and 2.1% for men aged 15-49 years[4]. The population in Kisarawe is predominantly Muslim, and the main ethnic group is the Zaramo.

We employed a two-stage sampling strategy to randomly select participants. First, to create the bounds of our sampling frame we mapped all households representing two communities within Kisarawe encompassing 10 villages and recorded household coordinates using GPS mapping. Secondly, we randomly selected a list of households to visit. Lists were generated in batches with all households per batch being visited to avoid bias. At the household level, all household members were enumerated and a household member within the eligible age range (18 to 55 years) was selected

using a random assignment application on an electronic tablet that was built into the survey. All data were collected on a Samsung Tab 2 tablet and were sent to and stored on a secure server. All households and eligible participants were visited up to three times. If a potential participant could not be located after three study visits, no substitutions from within the household were made.

Eligibility criteria included living full-time in the household, aged between 18 to 55 years, and plans to live in the household for the next two years (for the duration of the Triage Project). Written informed consent was provided by both the head of household and participant. All interviews with participants took place in a private location in or near the household at the participant's choosing. Interviews were conducted in Kiswahili by interviewers trained in data collection and research ethics. In additional to the behavioral assessment, a biological assessment was conducted, which included counseling and rapid testing for HIV (using Determine and Unigold HIV 1/2 rapid tests). Participants could receive their results immediately following testing, or they could chose not to receive their results or receive them at a later time. All specimens reactive on any HIV rapid test were retested at a laboratory using standard ELISA methods. Participants were compensated for their time with 1 kg bags of rice and beans. The study was approved by institutional review boards at the Medical University of South Carolina and Muhimbili University of Health and Allied Sciences.

Theory

This analysis uses concepts from Social Action Theory (SAT), which emphasizes three main interconnected sets of factors that drive health behavior: 1) the structural context in which health behaviors occur, 2) self-regulatory processes, including outcome expectancies and motivational appraisals that influence decision-making, and 3) drivers of health habit action states, including social interaction processes and social interdependence that impact drivers of behavior throughout the model[28]. This model is similar in breadth to the social ecological model, which contains factors at the individual-, interpersonal-, social-, and structural-levels[29] but differs in that more specific pathways between levels of factors are described. The Social Action Theory has been advocated for use in HIV prevention as it recognizes the interplay between structural, social, and individual level factors that drive risk[30]. For this analysis, we used logistic regression analyses to test the independent effects of three major SAT constructs on prior HIV testing: social interaction, contextual factors, and motivational expectancies involved with self-regulatory processes (e.g., behaviors, beliefs, and norms).

Measures

During the structured survey, participants were asked a series of questions related to their sexual risk behavior, prior HIV testing history, social norms related to HIV, and knowledge of HIV in their communities. Most survey items were adapted from measures used in Project Accept, which have previously been used in Kisarawe and other sites in sub-Saharan Africa to analyze factors related to HIV testing[18, 19, 31].

Participants who reported no prior HIV testing were asked about reasons they had never been tested given a list of 12 responses (listed in Table 2). Participants who reported prior testing were asked to provide reasons they tested within a list of 17 response choices (listed in Table 3). Participants could choose multiple responses. The two outcomes used in this analysis were "Have you ever been tested for HIV?" and "In the past 12 months, how many times have you been tested for HIV?" with responses dichotomized as "no recent testing" or "recently tested" if participants reported testing at least once for HIV in the past 12 months.

Variables related to self-regulatory processes in the Social Action Theory were chosen based on a literature review to assess potential items related to goals, expectations, and motivational appraisals of the outcome (prior HIV testing). Variables chosen included: 1) Anticipated stigma in the form of asking "Would you be hesitant to take an HIV test due to fear of people's reaction if you tested positive for HIV?", as this has been hypothesized to estimate the influence of stigma on HIV testing uptake[32]; 2) Having heard about ART, as this has been associated with HIV testing previously[33]; 3) Knowing someone who is living with HIV as qualitative data suggest the lack of positive narratives of people living with HIV exacerbate fear of testing[21]; 4) Social norms related to HIV prevention[34]; 5) Discriminatory attitudes towards people living with HIV[34, 35]; and 6) Ever talking about HIV with others, as this has been shown to be associated with HIV testing[31]. The social norm scale was constructed using 4 items related to norms about HIV testing, discussing HIV with sexual partners, and using condoms. Unidimensionality was assessed using exploratory factor analysis and internal consistency was measured

using Cronbach's alpha (α=0.71). The scale was dichotomized at the median for analysis. Discriminatory attitudes were assessed using three questions asking whether someone would be comfortable buying vegetables from someone living with HIV, whether children should go to school with children living with HIV, and whether a teacher living with HIV should be allowed to teach. Scores were assessed similarly to those of social norms (α=0.79).

The analysis examining correlates of recent HIV testing (within the past year) was restricted to participants reporting a main or regular sexual partner to understand potentially relevant partner-level influence, as some questions, such as "do you know if your partner has been tested for HIV?" were only asked for people reporting a main or regular partner in the past 6 months. Additionally, we added a variable pertaining to collective action by asking about participation in a meeting, march, rally, or gathering related to HIV prevention within the past two years. We also asked about recent behavior, including condom use frequency and having multiple sexual partners in the past 6 months to understand the relationship between recent behavior and recent HIV testing uptake.

Analysis

Reasons for testing and not testing were coded as a series of polytomous variables as participants could choose more than one reason. Separate chi-square analyses with a Bonferroni adjustment were run on each response to compare

distributions between males and females. Differences between key variables for males and females were also calculated using a Pearson chi-square statistic.

To analyze factors related to prior HIV testing, we built a series of gender-stratified logistic regression models following key variable groupings from the Social Action Theory. First, we ran bivariate logistic regression for contextual and demographic variables, including age, marital status, ethnic group and education, and the behavioral/normative predictors related to motivational expectancies outline above. We retained all variables significant at $p<0.10$ with prior HIV testing in multivariate models, in addition to controlling for key demographic variables, using backwards stepwise elimination. We restricted inclusion in the model to participants who reported being sexually active (i.e., had previously had sex) for both outcomes—any prior HIV testing and any recent HIV test.

To ascertain factors related to recent HIV testing, we restricted the analysis to look at recent behaviors and interpersonal factors of participants who reported receiving HIV testing within the past year and who reported having a recent main or regular partner. We ran bivariate logistic regression for factors related to recent behavior (e.g., condom use, recent conversations about HIV, and having multiple sex partners), collective action, and potential dyadic-level influence, including knowing whether a sexual partner has been tested for HIV. We then ran multivariate models controlling for sociodemographic and behavioral/normative variables previously identified. In all multivariate analyses we also controlled for the village from which

participants were sampled to account for geographical variations in variables of interest. All analyses were conducted using Stata (STATACORP, version 11, College Station TX).

Results

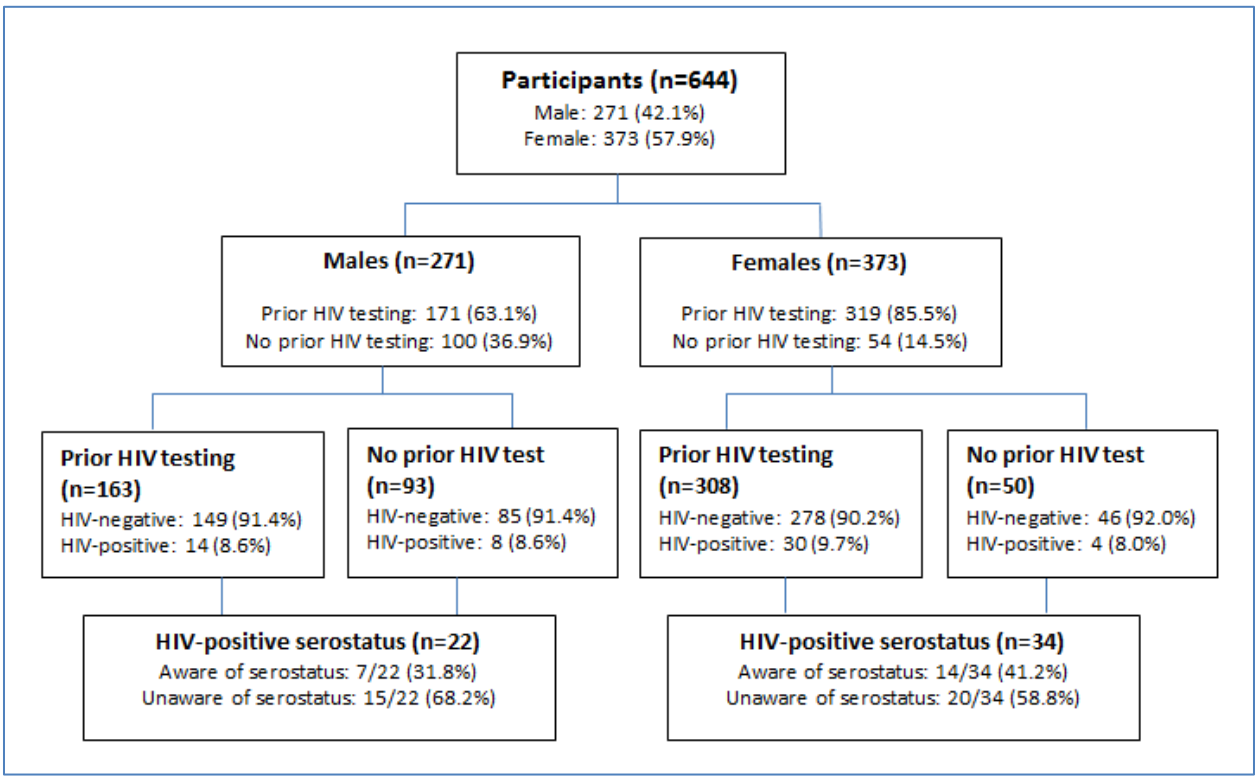
Sample characteristics and HIV prevalence

Of the 644 sexually active participants included in the analysis, 373 (58%) were female. Overall significantly more women than men reported prior HIV testing, with rates of prior HIV testing over 90% in some age groups. Sixty-three percent of male participants and 86% of female participants reported prior HIV testing. The overall HIV prevalence was 9.1% with no significant difference between genders. Of the 56 participants confirmed to have HIV infection, 22 were male and 34 were female. Over 68% of HIV-positive male participants were unaware of their serostatus at the time of testing (n=15/22). For females, 58.8% (n=20/34) reported being previously unaware of their HIV-positive serostatus. A flowchart of participants is presented in Figure 1 and key characteristics of the sample, disaggregated by gender, are presented in Table 1. The mean age for men was 37.7 years (SD=10.6) for men and 34.8 (SD=10.4) for women. The vast majority of participants were self-employed farmers or vendors (85.6%). Regarding education, 18% of the sample reported receiving no education, 70.5% received primary education, and 11.5% received secondary education or higher.

Table 1. Sample characteristics (n=644) disaggregated and compared by gender

Variable	Total N (%)	Men (n=271) N (%)	Women (n=373) N (%)	p-value
Gender				
Male	271 (42.1)			
Female	373 (57.9)			
Prior HIV Testing				
No	154 (23.9)	100 (36.9)	54 (14.5)	<0.01
Yes	490 (76.1)	171 (63.1)	319 (85.5)	
HIV test within the last 12 months				
No	397 (61.7)	193 (71.2)	169 (45.3)	<0.01
Yes	247 (38.3)	78 (28.8)	204 (54.7)	
HIV status				
Negative	558 (90.9)	234 (91.4)	324 (90.5)	0.70
Positive	56 (9.12)	22 (8.6)	34 (9.5)	
Age				
18-25	132 (20.5)	45 (16.6)	87 (23.3)	<0.01
26-35	189 (29.4)	67 (24.7)	122 (32.7)	
36-45	184 (28.6)	93 (34.3)	91 (24.4)	
45+	139 (21.6)	66 (24.4)	73 (19.6)	
Education				
No education	116 (18.0)	39 (14.4)	77 (20.6)	0.12
Primary	454 (70.5)	199 (73.4)	255 (68.4)	
Secondary or above	74 (11.5)	33 (12.2)	41 (11.0)	
Employment				
Self-employed	551 (85.6)	239 (88.2)	312 (83.6)	<0.01
Employed (salaried)	37 (5.8)	22 (8.1)	12 (4.0)	
Not employed	56 (8.7)	10 (3.7)	46 (12.3)	
Have a main sexual partner				
Yes	356 (64.6)	158 (66.7)	198 (63.1)	0.38
No	195 (35.4)	79 (33.3)	116 (36.4)	
Have heard about ART				
No	211 (32.8)	89 (32.8)	211(32.7)	0.52
Yes	433 (67.2)	182 (67.2)	251 (67.2)	
Condom use in past 6 months				
Never	405 (73.4)	162 (68.4)	243 (77.9)	0.04
Sometimes	102 (18.6)	52 (21.9)	50 (16.0)	
Always	42 (7.6)	23 (9.7)	19 (6.1)	

Figure 1. Distribution of study participants according to gender, HIV status, and prior testing



Reasons for testing and not testing for HIV

Men and women reported similar reasons for not testing for HIV; no statistical differences by gender were detected. A total of 149 participants who had never tested for HIV reported 169 different reasons for not testing with 13% reporting more than one reason. The most common reasons for not testing included "didn't think I was at risk" and "not important to me." Table 2 presents common reasons for not testing, stratified by gender. Table 3 presents common reasons for ever testing for HIV. Reasons reported for ever testing did differ by gender with a significantly larger proportion of women (n=150, 56%) reporting non-voluntary testing (defined as testing related to pregnancy, military, or insurance reasons) or as compared to men (χ^2 $p<0.001$). Other common

reasons for receiving prior HIV testing included "wanting to know status" and "not wanting to worry anymore." Of 405 respondents, 106 (26%) reported 2 or 3 reasons for prior testing.

Table 2. Reported reasons for not testing for HIV stratified by gender

Reason for not testing	Male N(%)	Female N(%)	Total N(%)[a]
Don't think I am at risk	**30 (28.0)**	**19 (30.6)**	**49 (29.0)**
Nervous to get results	4 (3.7)	4 (6.5)	8 (4.7)
Don't know where to get tested	4 (3.7)	0 (0.0)	4 (2.4)
Worried people would think I was sick	3 (2.8)	3 (4.8)	6 (3.6)
Test too expensive	0 (0.0)	1 (1.6)	1 (0.6)
Don't have time or opportunity	**12 (11.2)**	**11 (17.7)**	**23 (13.6)**
Testing site too far from home	5 (4.7)	1 (1.6)	6 (3.6)
Can't leave work to get tested	2 (1.9)	0 (0.0)	2 (1.2)
Results take too long	2 (1.9)	0 (0.0)	2 (1.2)
Didn't ever think of getting test	**14 (13.1)**	**8 (12.9)**	**22 (13.0)**
Not important to me	**30 (28.0)**	**15 (24.2)**	**45 (26.6)**
Doubt confidentiality of test results	1 (0.9)	0 (0.0)	1 (0.6)
Total	107	62	169

[a] Based on total number of responses, not total number of participants (n=149)

Notes: Most common reasons for not testing are bolded. One response choice, "Worried about sexual partner's reaction," was not selected by any participant as a reason for not testing.

Table 3. Reported reasons for HIV testing stratified by gender

Reason for testing	Male N(%)	Female N(%)	Total N(%)[a]
Non-voluntary test (pregnancy/tested at antenatal clinic, military, or insurance reasons)	**38 (22.1)**	**150 (44.3)**	**188 (36.8)**
Recommended by healthcare provider	**15 (8.7)**	**17 (5.0)**	**32 (6.3)**
Was sick/having symptoms of HIV/AIDS	4 (2.3)	4 (1.2)	8 (1.6)
Sexual partner got tested	1 (0.6)	1 (0.3)	2 (0.4)
Sexual partner got sick	0 (0.0)	1 (0.3)	1 (0.2)
Sexual partner asked that I get tested	2 (1.2)	3 (0.9)	5 (1.0)
Getting married	3 (1.7)	3 (0.9)	6 (1.2)
Having children	2 (1.2)	5 (1.5)	7 (1.4)
Wanted to know status	**71 (41.3)**	**108 (31.9)**	**179 (35.0)**
Had risky behavior	3 (1.7)	0 (0.0)	3 (0.6)
Sexual partner had risky behavior	0 (0.0)	4 (1.2)	4 (0.8)
Didn't want to worry anymore	**26 (15.1)**	**41 (12.1)**	**67 (13.1)**
Tested at work program	0 (0.0)	2 (0.6)	2 (0.4)
Other[b]	7 (4.1)	0 (0.0)	7 1.4)
Total	172	339	511

[a] Based on total number of responses, not total number of participants (n=405)

[b] Other reasons included: donating blood (n=3), free test (n=2), or easy access to test (n=2)

Notes: Most common reasons for testing are bolded. Four response choices were not selected by any participant. These included: "Applied for job," "Sexual partner is infected with HIV," "Casual contact with HIV-positive person," and "Quick results"

Associations of prior testing and contextual factors

HIV status was not significantly associated with prior testing for either men or women. For men, prior HIV testing was associated with age and education in bivariate analysis. Young men (aged 18-25 years) were less likely to report prior testing compared to middle-aged men, and men with primary education were more likely to report prior testing compared to men with no education. In multivariate analysis men aged 26-35 had over three times the odds of reporting prior testing compared to men aged 18-25 (aOR= 3.56, 955 CI: 1.34-9.45, p<0.01). For women, only age was significantly associated with prior testing in bivariate and multivariate regression, with young women (18-25 years) and older women (aged 46 years and above) reporting less prior testing than women aged 26-45 years. Almost all women aged 25-36 reported prior HIV testing (97.5%). In multivariate regression, women aged 25-36 had over 6 times the odds of prior testing as compared to younger women (aged 18-25) (aOR=6.03, 95% CI: 1.57-23.16, p<0.01). Older women aged 46 years and above were less likely to report prior testing as compared to young women. Results for bivariate and multivariate analyses are presented in Table 4 and Table 5, respectively.

Associations of prior testing and behavioral, beliefs, and normative factors

For men, bivariate analysis indicated that prior testing was inversely associated with lifetime alcohol use and fear of testing due to people's reaction if the result is positive. Odds of prior testing were higher among men who reported ever having had conversations about HIV and knowing someone who is living with HIV. Social norms

relating to HIV prevention, having discriminatory attitudes towards people living with HIV, and having heard about ART were not significantly related to odds of prior testing. In the final model, three factors remained significantly associated with prior HIV testing: lifetime alcohol use (aOR=0.56, 95%CI: 0.29-1.02, p=0.06), fear of being tested (aOR=0.31, 95% CI: 0.10-0.86, p=0.03), and ever talking about HIV (aOR=2.28, 95% CI: 1.20-4.31, p=0.01). For women, odds of prior testing were positively associated with having heard of ART and knowing someone who is living with HIV in bivariate analysis. In multivariate analysis, knowing someone who is living with HIV remained a significant predictor or prior testing (aOR= 2.74, 95% CI: 1.24-6.07, p=0.01).

Table 4: Bivariate correlates of prior HIV testing among sexually active participants (n=644)

	Male			Female		
Variable	Prior HIV test N(%)	Unadjusted OR (95% CI)	P value	Prior HIV test N(%)	Unadjusted OR (95% CI)	P value
Sociodemographic and contextual variables						
Age						
18-25	26 (57.8)	1.00		73 (83.9)	1.00	
26-35	52 (77.6)	2.53 (1.11-5.78)	0.03	119 (97.5)	7.61 (2.11-27.4)	<0.01
36-45	61 (65.6)	1.39 (0.67-2.89)	0.37	81 (89.0)	1.55 (0.65-3.71)	0.32
45+	32 (48.5)	0.69 (0.32-1.47)	0.34	46 (63.0)	0.33 (0.16-0.68)	<0.01
Marital status						
Single	48 (57.1)	1.00		82 (85.4)	1.00	
Ever married	123 (65.8)	1.44 (0.85-2.44)	0.17	237 (85.6)	1.01 (0.52-1.95)	0.97
Education						
No education	19 (48.7)	1.00		63 (81.8)	1.00	
Primary	130 (65.3)	1.98 (0.99-3.96)	0.05	222 (87.1)	1.49 (0.75-2.96)	0.25
Secondary and above	22 (66.7)	2.11 (0.81-5.49)	0.13	34 (82.9)	1.08 (0.40-2.93)	0.88
Ethnic group						
Other	66 (62.9)	1.00		100 (87.7)	1.00	
Zaramo	105 63.2	1.02 (0.61-1.69)	0.95	219 (84.6)	0.77 (0.40-1.47)	0.43
HIV Status						
Negative	149 (63.9)	1.00		278 (85.8)	1.00	
Positive	14 (63.6)	1.00 (0.40-2.48)	0.99	30 (88.24)	1.24 (0.42-3.69)	0.70
Norms, attitudes, beliefs, and behavior variables						
Fear of being tested						
No	162 (64.5)	1.00		301 (85.5)	1.00	
Yes	9 (45.0)	0.44 (0.18-1.13)	0.09	15 (88.2)	1.27 (0.28-5.72)	0.76
Know about ART						
No	51 (57.3)	1.00		99 (81.2)	1.00	
Yes	120 (65.9)	1.44 (0.86-2.43)	0.17	220 (87.6)	1.65 (0.91-2.97)	0.10
Know HIV+ person						
No	91 (59.1)	1.00		194 (90.0)	1.00	
Yes	78 (69.0)	1.54 (0.92-2.57)	0.10	120 (90.9)	1.91 (0.96-3.80)	0.07

Social norms about HIV prevention						
Unfavorable	45 (60.0)	1.00		85 (81.0)	1.00	
Favorable	103 (62.1)	1.10 (0.62-1.90)	0.76	174 (87.0)	1.57 (0.83-2.98)	0.16
Discrimination						
Low	110 (64.0)	1.00		206 (87.3)	1.00	
High	61 (61.2)	0.90 (0.54-1.51)	0.70	111 (82.2)	0.67 (0.38-1.21)	0.19
Ever talk about HIV						
No	40 (52.0)	1.00		111 (82.2)	1.00	
Yes	131 (67.5)	1.92 (1.12-3.29)	0.02	207 (87.7)	1.54 (0.86-2.78)	0.15
Alcohol use in lifetime						
No	84 (71.8)	1.00		225 (87.6)	1.00	
Yes	87 (56.5)	0.51 (0.31-0.85)	0.01	94 (81.0)	0.61 (0.33-1.10)	0.10

Table 5. Multivariate logistic regression model for correlates of prior HIV testing among sexually active participants in Kisarawe (n=644)

Variable	Male		Female	
	Adjusted OR[a] (95% CI)	P value	Adjusted OR[a] (95% CI)	P value
Sociodemographic and contextual variables				
Age				
18-25	1.00		1.00	
26-35	3.56 (1.34-9.45)	0.01	6.03 (1.57-23.16)	<0.01
36-45	1.61 (0.62-4.19)	0.33	1.09 (0.39-3.00)	0.87
45+	0.77 (0.28-2.14)	0.62	0.21 (0.08-0.56)	<0.01
Marital status				
Single	1.00		1.00	
Ever married	1.93 (0.97-3.83)	0.06	1.30 (0.55-3.05)	0.55
Education				
No education	1.00	0.19	1.00	
Primary	1.70 (0.77-3.77)	0.14	1.31 (0.59-2.93)	
Secondary and above	2.30 (0.76-6.92)		0.52 (0.15-1.78)	0.30
Ethnic group				
Other	1.00		1.00	
Zaramo	1.38 (0.74-2.56)	0.31	0.90 (0.42-1.95)	0.79
Norms, attitudes, beliefs, and behavior variables				
Fear of being tested				
No	1.00			
Yes	0.31 (0.11-0.86)	0.03		
Know HIV+ person				
No			1.00	
Yes			2.74 (1.24-6.07)	0.01
Ever talk about HIV				
No	1.00			
Yes	2.28 (1.20-4.31)	0.01		
Alcohol use in lifetime				
No	1.00			
Yes	0.56 (0.29-1.02)	0.06		

[a]Adjusted for all variables listed in addition to village

Associations between recent prior testing and behavioral factors, social interaction, and partner influence

This analysis was restricted to the 551 participants who reported having a main or regular sexual partner in the last six months. In bivariate analysis, no recent sexual behavior variables included in the models for men and women were significantly associated with recent HIV testing. These variables included condom frequency (never, sometimes, always) and having more than one sexual partner in the past 6 months. For men, knowing whether their sexual partner had tested for HIV and having participated in a recent meeting, march, rally, or gathering about HIV prevention were significantly associated with recent testing. In multivariate analysis, men who reported knowing that their partner had tested for HIV had over twice the odds of reporting recent testing as compared to men who did not know if their partner had been tested for HIV (aOR= 2.64 , 95% CI: 1.35-5.18, $p<0.01$). For women, knowing whether their partner had received an HIV test was correlated with recent testing in bivariate analysis ($p<0.10$), but this association did not remain significant in multivariate analysis. No other recent behavioral or social factors were related to recent HIV testing for women. Results are presented in Table 6.

Table 6. Bivariate and multivariate logistic regression model of factors related to recent HIV testing (within the past 12 months) for sexually active men and women reporting a main or regular partner in the past 6 months (n=551)

	Male				Female			
Variable	Unadjusted OR (95% CI)	P value	Adjusted OR[a] (95% CI)	P value	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Condom use								
Never	1.00							
Sometimes	1.01 (0.45-2.27)	0.97			1.41 (0.68-2.90)	0.35		
Always	0.71 (0.21-2.41)	0.58			1.78 (0.52-6.10)	0.36		
Number of sex partners								
0-1	1.00				1.00			
>1	0.73 (0.36-1.50)	0.40			0.90 (0.39-2.1)	0.81		
Know partner tested for HIV								
No	1.00		1.00		1.00			
Yes	2.64 (1.35-5.18)	<0.01	2.96 (1.22-7.17)	0.01	1.85 (0.91-3.78)	0.09		
Living situation								
With partner	1.49 (0.89-2.50)	0.13	.		1.10 (0.61-1.97)	0.75		
Other	1.00				1.00			
Recent talk about HIV								
None	1.00				1.00			
At least one	1.16 (0.61-2.23)	0.65			1.33 (0.74-2.37)	0.34		
Participation in HIV activities								
No	1.00	0.04			1.00			
Yes	2.10 (1.04-4.26)				1.73 (0.86-3.45)	0.12		

[a] Adjusted for village, age, education, ethnic group, alcohol use, fear of testing, and talking about HIV.

Discussion

In this study using a random, population-based sample from Kisarawe, Tanzania, reasons for HIV testing and factors related to HIV testing uptake differed between men and women. Uptake of testing was significantly lower for men than women, which is consistent with other findings from Tanzania[36] as well as with the overall awareness that men get tested less, due to HIV testing's incongruence with traditional gender norms[20, 37, 38] and men's reduced exposure to routine testing as compared to women. Uptake of testing was also low for young people aged 18-25, regardless of gender. This finding is concerning, especially for young women as HIV prevalence among women aged 20-24

years is 4.4% in Tanzania[4], and is consistent with results from a global review that found most adolescents are unaware of their HIV status [39]. Interventions targeted toward increasing HIV testing among young people and adolescents are urgently needed. Regarding reasons for testing and not testing for HIV, findings between men and women were similar except that women overwhelmingly reported being tested as a result of pregnancy/antenatal services, which reflects the growing scale-up of routine testing offered through PMTCT programs[40].

Common reasons for not testing indicated no significant structural barriers to testing, such as not knowing where one could be tested. Instead, most people reported not testing because either they felt they were not at risk or that testing was not important to them. This merits further exploration and suggests that more proactive HIV testing strategies that make services more accessible, such as home-based testing or mobile testing, are needed. A study from Zambia demonstrated that home-based testing is highly acceptable and not associated with increased negative life events[41]. Investigators from this study also note that because home-based testing takes place outside the clinic, it may encourage gender equality in HIV testing while still accommodating traditional gender norms, such as by allowing the man to take responsibility for his household's health [42]. Mobile testing is another HIV testing strategy that has shown promise, especially in increasing male uptake, such as was seen in Project Accept[26], and increasing uptake among men with greater HIV-related risk[43].

Regarding women, over half of female participants reported being tested for HIV during pregnancy as part of antenatal care. Almost all women aged 26 to 35 years reported prior HIV testing, which presumably demonstrates the success of routine HIV testing being implemented in PMTCT programs in Tanzania. We hypothesize that because so many women have been tested due to pregnancy/antenatal care, correlates of social and behavioral factors and HIV testing are obscured because women are being tested as part of a routine service. While increases in testing due to PITC in antenatal settings are encouraging, efforts are needed to ensure testing in routine settings remains voluntary. Concerning research from Malawi suggests that women receiving PITC during antenatal care do not see the test as a choice but as something they must do in order to receive services[44]. Additionally, recent findings from Tanzania suggests that some women are effectively coerced into couples HIV testing and counseling during antenatal services as women report being denied care until they bring their sexual partners in for testing[45]. It is imperative that testing programs, regardless of how routine or provider-initiated, must be rights-based, voluntary, and not used as a condition for access to any other health service. There are examples of interventions working to increase male involvement in PMTCT through voluntary means, such as providing invitations to men and offering testing outside of the antenatal care setting[7]. Involvement of men in PMTCT programs might explain why knowledge of partner testing was associated with recent testing for men but not for women, or this finding might signify that women who test are disclosing their serostatus to their partners who are in turn testing for HIV outside of the PMTCT context.

For men, ever talking about HIV was related to prior testing. These findings are consistent with results from Project Accept, which found that having prior conversations about HIV was significantly associated with testing across all study sites[31]. Fear of testing due to people's reaction if the test is positive is also consistent with other findings in the literature. In one study from Lesotho both men and women overwhelmingly described men as being scared and reluctant to test[21]. The fear of testing HIV-positive might be rooted in gender norms, as testing HIV-positive could show weakness, embarrassment, or damage to sexual prowess[20, 21, 46]. The inverse association between lifetime alcohol use and prior testing, which was marginally significant in this study, has not been identified previously and warrants further exploration. Given the indirect association between alcohol and HIV infection, designing interventions to target men who frequent drinking establishments for HIV testing could be a successful way to increase HIV testing among this high-risk group. A review of structural and social interventions within alcohol-serving establishments found that offering onsite HIV testing was feasible and acceptable, although this had only been tried in a few settings, none in sub-Saharan Africa[47].

For assessing factors related to recent testing, variables related to dyadic-level influence showed significant correlation for men, which speaks to the importance of partner communication related to HIV testing. Knowing whether a sexual partner had been tested for HIV was significantly correlated with recent testing for men but not women, which is consistent with findings from South Africa[35], although this study did not disaggregate findings by gender. The influence of social interactions on health

behaviors is a central theme of Social Action Theory,[28] and results demonstrate overall support for using SAT to explore multi-level factors related to testing behavior. Similar to SAT, a another theoretical framework emphasizing the importance of dyadic interactions in HIV prevention recognizes the phenomenon of "reciprocal influence" where a partner can heavily influence an individual's decision whether to engage in a health behavior regardless of his/her own personal norms, attitudes, and beliefs[48]. These findings highlight the potential for interventions seeking to motivate members of couples to recruit their partners for testing. In PMTCT programs this can take the form of providing invitation letters to male partners of female antenatal attendees to encourage male partner involvement and participation in couples counseling and testing. A study in Malawi demonstrated that providing such a letter increased male involvement by 50%[49]. Other interventions aimed at reaching both members of a couple involve some form of partner notification for people who test HIV-positive. Partner notification studies in low- and middle-income countries are limited but shown moderate success in Malawi and Cameroon for increasing the proportion of partners who returned for testing[50, 51]. Identifying creative ways to influence partners and increase partner communication about HIV could help increase uptake of HIV testing among dyads.

Engaging in high-risk sexual practices, such as having multiple partners and not using condoms, was not associated with recent testing for either males or females, which is concerning. This corroborates findings from a study across 16 regions of Tanzania that found no association between risk perception and HIV testing[52],

suggesting that people either do not perceive themselves to be at-risk or believe they are at-risk but choose not to test due to fear of receiving a positive result, which are both reasons provided by participants in qualitative work to explain why people are not testing [53]. However, given our cross-sectional data, causation cannot be determined and perhaps people who have tested negative cease using protective measures, such as condoms, which would explain the lack of effect between risk and HIV testing.

Limitations

This study has several limitations. We used cross-sectional data which were mostly based on self-report, so causality cannot be inferred and social desirability bias may have influenced results. For the model assessing factors relating to HIV testing within the past year, we do not know whether the reported behaviors and partner-level influence occurred before or after the test, so behaviors could have influenced testing or vice versa. For variables related to communication and knowing whether a sexual partner had been tested, we know nothing about the context of the communication. The models also included several latent variables, such as anticipated stigma, discrimination, and social norms around HIV prevention, that have not been extensively validated in other settings. The list of variables included in the model was not exhaustive and unmeasured confounding could have occurred.

Conclusions

HIV testing is the first critical step in the HIV care cascade, and increasing testing could help halt the epidemic through increasing the proportion of people living with HIV on ART and through promoting awareness and behavior change among people who are

uninfected. HIV testing is a gendered experience in Tanzania. Women are often tested as a result of receiving antenatal care, and men who have tested are more likely to have had some social interaction, such as talking about HIV or knowing if their partner tested, which may have influenced their decision to test. The immense need to better target HIV testing to those who might be HIV-positive or at high-risk of infection is clearly evident in that over 50% of HIV-positive participants, including men and women, were unaware of their serostatus at the time of the survey. Gender-specific interventions to increase testing, as well as interventions that seek to increase testing among members of high-risk sexual partnerships are warranted, especially given the importance of HIV testing as the gateway. In the immediate future interventions are needed to increase HIV testing, particularly for people who are at high-risk of being or becoming HIV-infected, while ensuring interventions do not increase harm or compromise human rights. In the long-term Interventions are needed to address gender inequities and promote healthy relationships to influence safer, more equitable health decision making.

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MANUSCRIPT 2:

PRIORITIZING CLIENTS AT HEIGHTENED RISK OF HIV INFECTION DURING HIV TESTING AND COUNSELING IN KISARAWE, TANZANIA: BUILDING RISK ASSESSMENT TOOLS USING CATEGORIZATION AND REGRESSION TREE ANALYSIS

Abstract

Background: The Triage Project, a phase II randomized trial in Kisarawe, Tanzania, will triage individuals at high risk for HIV infection during HIV testing and counseling so these individuals can receive additional services, including additional counseling. Although factors associated with HIV infection are generally known, there is a dearth of field-based risk assessment tools to identify high-risk individuals based on specific client characteristics and epidemic profile. We used CaRT analysis on HIV prevalence from a large probability-based sample gathered in a previous study in Kisarawe (Project Accept) to identify participant profiles for provision of tailored intervention services.

Methods: We used simple logistic regression models to identify salient variables separately for males and females. Variables significant at $p<0.10$ were retained for the CaRT analysis. SPSS was used to build categorization trees. We used the Gini improvement measure to split notes, and k-fold cross-validation (k=10) as a means of internal validation. Models were compared to multivariate regression models using backwards selection to ascertain comparability.

Results: For males (n=927), CaRT produced a categorization tree with 10 nodes using 4 predictors, resulting in a 6-item risk assessment questionnaire. Men who reported ≥5 lifetime sexual partners and men who used alcohol, aged >25 years, and reported inconsistent condom use were categorized as high risk. For women (n=1367), CaRT produced a tree with 23 nodes using 7 predictors, resulting in a 10-item risk assessment questionnaire. Younger women reporting no prior HIV test and multiple lifetime sexual

partners and older women who reported recent intimate partner violence or inconsistent condom use were categorized as high-risk. Both trees correctly classified approximately 75% of HIV infections.

Conclusions: Though using CaRT analysis, we developed risk assessment tools that were generally successful in categorizing HTC HIV-uninfected clients as at high- or low-risk for HIV infection. The tools used simple questions and a graphical presentation of data for ease of interpretation. The segmentation of risk provides a foundation for developing practical field tools allowing for specific tailoring of service delivery matched to need. This could help programs develop more cost-effective strategies, and the utility and feasibility of this strategy will be tested in the ongoing study.

Background

The main goal of HIV testing and counseling (HTC) is to learn one's HIV status, which is a critical first step in the HIV care continuum and an important avenue for HIV prevention. For those who test HIV-positive, HTC is the gateway to accessing antiretroviral therapy. For those who test HIV-negative, HTC can serve as an effective means of behavior change in and of itself. Two systematic reviews have demonstrated that participants who undergo voluntary counseling and testing (VCT) generally report more condom use[1] and fewer sexual partners[2] as compared to those who have not undergone VCT, regardless of serostatus. Today, in light of new HIV prevention tools, HTC plays an expanded role in HIV prevention, which not only pertains to learning one's HIV serostatus, but also to accessing HIV-related care and treatment, prevention of mother-to-child transmission, medical male circumcision, and pre-exposure prophylaxis for those who are HV-negative.

However, instead of appreciating HTC only as a means to an end, HTC can also be viewed as an opportunity. HTC is, in many cases, an individuals' first and sometimes only HIV service-related encounter, and it is important to maximize the benefits of this encounter, especially for clients who test HIV-negative so as to prevent future HIV infections. Despite HTC's importance in HIV prevention, few efforts have been made to enhance HTC for those who test HIV-negative, although several new, effective service delivery modalities, including community-based counseling and testing[3], self-testing[4],

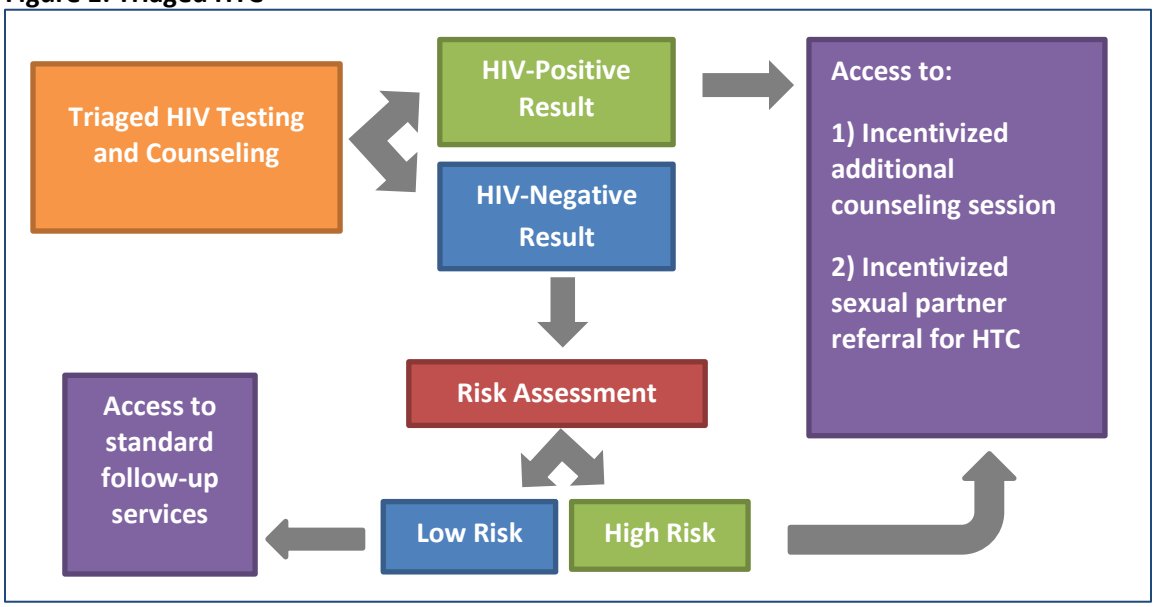
and provider-initiated testing and counseling[5], have successfully increased the number of people tested worldwide.

One current limitation of HTC's preventative benefits is that it treats all people who test HIV-negative similarly. Paying more attention to those who test HIV negative but exhibit certain risk behaviors could increase the preventative value of testing. Following HTC, people who test HIV-negative will return to their lives, some of which involve continued HIV risk, such as engaging in unprotected sex with partners of unknown HIV status, while others involve little risk, such as abstaining from sex following separation from a spouse. Prioritizing those at heightened risk of HIV infection and providing additional services, such as additional counseling and partner referral, has the potential to maximize the prevention benefits of receiving HTC.

One way to identify HIV-negative clients who would benefit the most from additional HIV prevention interventions is through triage. Triage is a decision-making process most commonly used in medicine to prioritize patients with the greatest care needs when resources are limited, particularly in mass trauma and disaster settings[6]. First used in World War I to prioritize treatment of wounded soldiers, triage is now commonly used in hospital settings across the globe, particularly in emergency rooms[7]. Triage represents a model where practitioners categorize and sort "health related person-environment interactions" on a case-by-case basis using judgment, previous experience, and possibly written guidelines to inform decisions[8].

In Kisarawe, Tanzania, the Triage Project is using the principle of triage during HTC to identify individuals who test HIV-negative but are at heightened risk of infection, and provide them access to additional resources. In brief, the intervention involves community-based triaged HTC, support services, and enhanced linkages to care. The additional services offered to individuals at heightened risk of HIV infection include receiving a small commodity-based incentive, such as a bar of soap or a bag of rice, for returning one week following HTC for an additional counseling session. Additionally, individuals at heightened risk will be offered up to three referral cards to give to sexual partners. If the partners come in for HTC, they will also receive an incentive. Figure 1 presents a schematic of triaged HTC.

Figure 1: Triaged HTC



Triaging participants necessitates some form of risk assessment to determine who is in most need of additional services. In relation to HTC, this risk assessment involves categorizing those who test HIV-negative into high- and low-risk categories. The

applications for other HIV-related interventions could be to identify participants in most need of another service, such as medical male circumcision or pre-exposure prophylaxis (PrEP). Although studies abound on risk factors related to HIV infection, few attempts have been made to produce a practical and data-driven tool to categorize HIV-related risk. One notable exception is efforts from the Partners PrEP study to develop a clinically usable risk assessment tool to identify participants in serodiscordant relationships who would benefit from taking PrEP[9]. The risk assessment tool was developed using simple, known or suspected predictors, data from three separate trials on HIV incidence among serodiscordant couples, and principles of clinical decision rules to create an additive risk assessment score model[9].

The aim of this analysis was to develop evidence-based, clinically-relevant decision trees using Categorization and Regression Tree (CaRT) analysis to categorize HTC clients as either high- or low-risk for HIV infection. Although this analysis was focused on creating risk assessment tools for HTC, the use of such tools potentially extends to other HIV prevention interventions as well, particularly in situations where resources are scarce.

Methods

Data source and study population

We developed risk assessment tools using post-intervention data from a previous study in Kisarawe: Project Accept. This project was a multi-site community randomized trial assessing the efficacy of an HIV prevention intervention involving

community mobilization, access to community-based VCT, and post-test support services. Although Project Accept took place in five sites in four different countries, only data from the Tanzania site were used in this analysis. Reports on methods and results of Project Accept are published elsewhere[10-12]. Data from Project Accept include extensive behavioral and biological data from 2,500 participants in Tanzania. Although data were cross-sectional, cases of incident HIV infection were available based on results from a multi-assay algorithm developed specifically for Project Accept[13].

Behavioral and biological post-intervention assessments were conducted in 2009-2010 in Kisarawe district, Tanzania, which is a rural district located about 40km southwest of Dar es Salaam. Randomly selected households were approached and, with the head of household's permission, one eligible participant was randomly selected to complete a detailed behavioral assessment and blood draw. Methods for testing blood specimens for HIV have been described in detail elsewhere[13, 14].

Eligibility criteria included: aged between 18-32 years, residency within the community, and ability to provide informed consent[10]. Participants in the post-intervention assessment came from ten communities, five of which had been randomized to receive the intervention, with the remaining five receiving the control condition. Subjects were included in this analysis if they reported being sexually active, had valid HIV results and had completed the detailed behavioral assessment collected post-intervention.

Ethical approvals for all aspects of Project Accept were obtained within countries where data collection took place and at all academic institutions involved. Informed consent was obtained for each component of the data collection, including the blood draw and behavioral surveys.

Categorization and regression tree analysis

In order to develop risk assessment tools, we used categorization and regression tree (CaRT) analysis due to its proven utility in developing clinical decision rules, its ability to classify populations based on patterns of characteristics relevant to an outcome of interest (e.g., HIV infection), and the graphical presentation and ease of interpreting results[15, 16]. Breiman and colleagues first developed CaRT in the 1980s[17], and as computing power and data availability have increased, so has the popularity of CaRT, particularly in the field of clinical research, and more recently, public health[15]. CaRT has been utilized to identify groups at heightened risk for diverse outcomes, such as mothers at risk for having low birth weight babies[18], sexually abused females at risk for suicide ideation[19], and children at risk for recurrent maltreatment[20]. CaRT has also been utilized to develop clinical decision rules, such as determining criteria for hospital admission[21] and symptom criteria for diagnosing influenza[22].

CaRT analysis is a non-parametric form of binary recursive partitioning that segments a population into mutually exclusive groups, each of whom share a similar set of characteristics relating to an outcome of interest[17]. CaRT begins with one "parent node," which contains all subjects within the sample. Subsequently this node is split into

two “child nodes” based on the independent variable that creates two groups most dissimilar in terms of the outcome based on predetermined splitting criteria. In other words, if using HIV infection as the outcome of interest, CaRT would split the sample based on the characteristic that produces the largest difference between HIV-infected and HIV-uninfected groups. CaRT exhaustively computes all potential splits before selecting the variable that produces the best split. For continuous and categorical independent variables, CaRT also selects the cut-point or category that maximizes outcome homogeneity within child nodes and heterogeneity between nodes with respect to the outcome.

There are many different criteria that can be used to split nodes, with the most common being the Gini improvement measure, which uses a statistical formula to create values for each variable with respect to the outcome, with larger values signifying greater differences in the prevalence of the outcome between nodes[15]. Using this method, CaRT splits the node based on the independent variable with the largest value. The splitting process continues until terminal nodes are reached, which represent mutually exclusive sub-groups. Stopping rules are employed to prevent the tree from splitting further once certain criteria are met, thus resulting in terminal nodes. Stopping rules can include criteria such as maintaining a certain minimum of subjects per child node, a maximum number of levels for tree depth, and a minimum value of the splitting criteria that needs to be reached in order for a split to occur. Trees can also be “pruned” to create parsimonious models that factor into account misclassification costs[15]. Trees can be internally validated through dividing the data into learning and training sets, or

by using *k*-fold cross validation, which divides the dataset into *k* sub-sets and runs repeated analyses, removing one sub-set from analysis at a time. External validation requires using the tree on an entirely new population.

Importantly, using CaRT to address public health issues and clinical research is not without debate[23], and many limitations exist. First, because CaRT makes splits one variable at a time, adjustment for potential confounding variables is not possible. Unlike regression analyses, CaRT cannot isolate the effect of one variable on an outcome due to its hierarchical nature[15, 23]. Additionally, because all values of categorical and continuous variables within a dataset are tested to determine the best split, results of CaRT are sensitive to small changes in the data[24]. Despite these drawbacks, CaRT remains a powerful tool for developing risk assessment tools but should be used in conjunction with predetermined hypotheses and guidelines to minimize identifying spurious and clinically irrelevant associations.

Analytical steps in CaRT analysis and risk assessment tool development

Following guidelines for creating clinical decision rules[25], the analysis took place in several steps. First, we defined our outcome of interest as HIV status (HIV infected vs. uninfected) due to its relevance during VCT and ease of objective assessment. Ideally, we would have used incident HIV infection as the outcome of interest; however, due to the relatively small number of incident HIV cases identified in the dataset, HIV prevalence was used as a proxy measure, which is a substitution that has been used in similar scenarios[26]. However, using prevalence as an outcome limited the analysis

because causality could no longer be inferred. In the classification trees, HIV infection served as the parent node and all subsequent child nodes were created using variables that split that population into groups most different in terms of HIV infection.

Second, we generated an exhaustive list of potential variables associated with HIV infection. We developed *a priori* hypotheses regarding which independent variables to include in the model based on several factors, including evidence of association, simplicity, and clinical relevance. More specifically, we included variables only if there was established evidence of an association with HIV infection in the literature. Additionally, we selected variables with a direct link to HIV infection that could easily be explained during counseling. Therefore, complex, distal factors related to HIV, such as socio-economic status, education, etc., were purposefully excluded. Thirdly, we included only variables with answers attainable through asking one simple question. This rule excluded constructs such as gender equity, stigma, social capital, etc.

We further narrowed the list of potential variables by running bivariate logistic regression analysis to assess which variables were independently associated with HIV infection. Variables were retained if they were statistically significant at $p<0.10$ for each analysis. Following this step, CaRT analysis was run using SPSS v22 (IBM Corp, Armonk NY) with HIV infection as the outcome of interest; all variables that were significantly associated with HIV infection in the bivariate analyses were included in the models. CaRT analyses were run separately by gender due to substantial differences in HIV prevalence, demographics, and risk behaviors.

The binary splitting of continuous (e.g., age) and categorical variables (e.g., marital status) were determined through the CaRT analysis itself, which chose cut-points based on values that produced the most homogeneity within child nodes with respect to the outcome. We allowed trees to grow to a depth of 6 levels. We set the minimum number of subjects per parent node at 30 and 15 for each child node. The minimums were set relatively low due to the limited number of HIV cases present in the data (109 for females, 25 for men). We used the Gini improvement measure to split notes, and *k*-fold cross-validation (*k*=10) as a means of internal validation. To classify the terminal nodes as "high- risk" or "low-risk," we used the average HIV prevalence for males and females as cut-points. For example, HIV prevalence among females in the overall sample was 8.0%. If female subjects in a terminal node had an HIV prevalence higher than 8%, this node was classified as high-risk. If the HIV prevalence in a terminal node was less than 8.0%, this node was classified as low-risk. Among males the average HIV prevalence (2.7%) was also used as the cut-point.

We compared results from the classification trees to results from multivariate logistic regression with forward and backward stepwise selection using the Akaike Information Criteria for final model selection. We undertook this step to assess the similarities and differences between regression and CaRT analysis, including which variables were retained in the models (parsimony), the magnitude of association and significance of predictors in each model, and indications as to whether the models under-fit or over-fit the data. We dichotomized continuous and categorical variables for

the multivariate regression analyses using cut-points determined in CaRT in order to maximize comparability between the two analyses.

Finally, we transformed results from the CaRT analysis into risk assessment tools. Tool development involved pruning trees to streamline risk assessment, developing corresponding questionnaires, and ensuring the tools reflected logical, real-world risks. For males, this involved running a separate analysis using a behavioral proxy for HIV infection, reporting multiple sexual partners in the previous 6 months, for men aged 25 years or less, since there were only 2 cases of HIV infection reported in this population. For females, no additional analyses were conducted, but the risk assessment tool was streamlined by removing superfluous nodes. Thirdly, because HIV prevalence was used as the outcome of interest and not HIV incidence, causation could not be inferred, and sometimes, reverse causation was clearly occurring. For example, in both genders consistent condom use was associated with being HIV-infected. Presumably this finding occurred because people were aware of their HIV-positive status used condoms consistently to protect their sexual partners from infection. Therefore, although HIV prevalence was high among cases reporting consistent condom use, the risk category of these terminal nodes was changed from “high” to “low” risk to reflect the presumed reverse causality of this association.

Results

Study population

The study population comprised 926 males and 1367 females aged 18 to 32 years. The mean age was similar for both males and females, 25.8 and 26.3 years, respectively, although females were slightly older. Regarding marital status, over half the male population was single and 42% were married. For women, 22% were single, 67% were married, and 10% were either separated, divorced, or widowed. Most participants were Muslim and a majority of participants were part of the Zaramo ethnic group, a Swahili-speaking people living in the coastal plains and hills surrounding Dar es Salaam[27]. Over two thirds of participants, both male and female, were self-employed farmers, about 20% were self-employed vendors, and only 4% of males and 2% of females had employment with a fixed salary. Mean years of education were 6.5 for men and 5.8 for women. HIV prevalence varied dramatically between genders, with 2.7% of men and 8.0% of women being infected with HIV. Testing rates also varied between genders. Over 80% of women reported ever being tested for HIV whereas only 44% of men reported ever being tested. Sample characteristics are presented in Table 1.

Table 1: Sample sociodemographic characteristics

Characteristic	Female N=1367	Male N=926
	N (%)	*N (%)*
Age (*mean, SD*)	26.3 (4.3)	25.8 (4.8)
Marital status		
Single	296 (22%)	475 (51%)
Married	922 (67%)	391 (42%)
Married living separately	23 (2%)	8 (0.9%)
Separated	42 (3%)	28 (3%)
Divorced	64 (5%)	19 (2%)
Widowed	20 (2%)	5 (0.5%)
Years of education (*mean, SD*)	5.8 (3.1)	6.5 (3.0)
Religion		
Muslim	1245 (91%)	789 (85%)
Christian	120 (9%)	134 (15%)
Tribe		
Zaramo	1019 (75%)	641 (69%)
Other	346 (25%)	284 (31%)
Occupation		
Self-employed farmer	922 (67%)	557 (60%)
Self-employed vendor	253 (19%)	161 (17%)
Employed with fixed salary	28 (2%)	37 (4%)
Other	162 (12%)	170 (18%)
HIV status		
Infected	109 (8.0%)	25 (2.7%)
Not infected	1258 (92%)	901 (97%)
Ever tested for HIV		
Yes	1130 (82%)	407 (44%)
No	237 (17%)	519 (56%)

Bivariate analyses

Tables 2a-2b present results from the bivariate logistic regression analyses of the thirteen variables potentially associated with HIV infection. Among predictors tested through bivariate analysis, eight variables were significantly associated with HIV infection for women and five for men. For females, variables significantly associated with HIV infection included age, marital status, ever using alcohol, ever using drugs, number of lifetime sexual partners, consistent condom use (defined as always using a

condom when having sex in the past 6 months), being tested for HIV within the previous year, and being hit, slapped, or otherwise physically hurt by a sexual partner in the previous 6 months (hereto referred to as experiencing intimate partner violence). For males, variables significantly associated with HIV infection were age, number of lifetime sexual partners, consistent condom use, marital status, and ever using alcohol.

Table 2a: Female bivariate logistic regression—Odds of HIV infection among potential CaRT variables

Variable	Frequency (%)	Odds ratio (95% CI)	p-value
Age			
≤26	624 (46)	*ref*	
>26	743 (54)	3.05 (1.93-8.84)	<0.0001
Marital status			
Single	296 (22)	*ref*	
Married	922 (67)	1.14 (0.67-1.94)	0.62
Married living separately	23 (2)	0.66 (0.08-5.18)	0.70
Separated	42 (3)	1.53 (0.50-4.75)	0.46
Divorced	64 (5)	2.39 (1.03-5.55)	0.04
Widowed	20 (2)	11.93 (4.41-32.30)	<0.0001
Multiple sexual partners in previous 6 months	66 (5)	0.94 (0.37-2.40)	0.90
Sexual partner has hit, slapped or otherwise physical hurt	51 (5)	2.34 (1.06-5.17)	0.04
Received HIV test in previous year	611 (45)	0.52 (0.34-0.79)	0.002
Consistent condom use	58 (6)	2.23 (1.05-4.73)	0.04
Ever alcohol use	222 (16)	2.11 (1.35-3.30)	0.001
Ever drug use	5 (0.4)	7.81 (1.29-47.23)	0.025
Ever talked about HIV	721 (53)	0.84 (0.57-1.24)	0.37
Number of lifetime sexual partners			
1	526 (38)	*ref*	
2	374 (27)	2.33 (1.32-4.10)	0.003
3+	467 (34)	3.21 (1.91-5.40)	<0.0001
Have main sexual partner	896 (90)	1.68 (0.66-4.26)	0.27
Live with sexual partner	740 (82)	0.71 (0.40-1.25)	0.23
Age of first sex			
<18	502 (37)	*ref*	
≥18	864 (63)	(0.59-1.32)	0.54

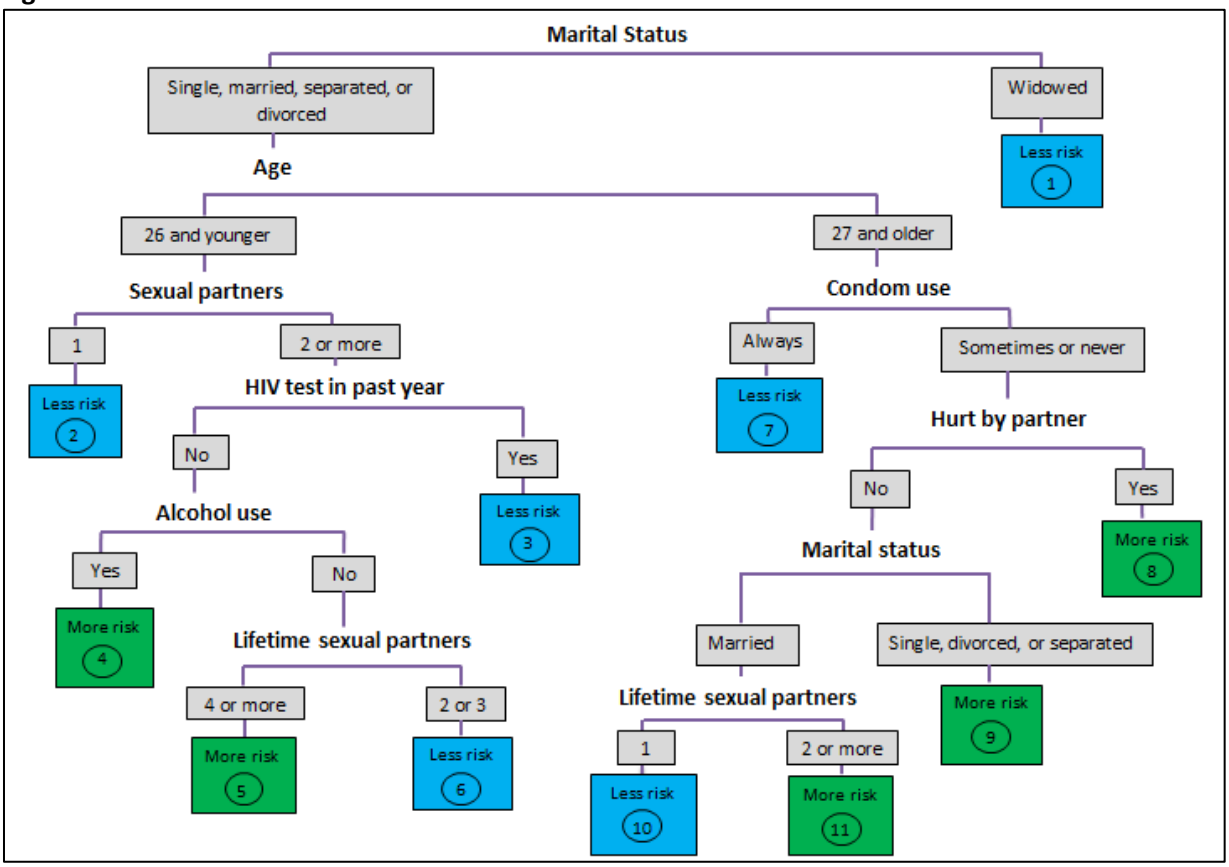
Table 2b: Male bivariate logistic regression—Odds of HIV infection among potential CaRT variables

Variable	Frequency (%)	Odds ratio (95% CI)	p-value
Age			
≤25	427 (46%)	*ref*	
>25	499 (54%)	6.52 (1.94-21.93)	0.002
Marital status			
Single	475 (51%)	*ref*	
Married	391 (42%)	3.23 (1.14-9.15)	0.027
Married living separately	8 (0.8%)	13.43 (1.38-130.38)	0.025
Separated	28 (3%0	15.67 (3.95-62.10)	<0.0001
Divorced	19 (2%)	11.10 (2.00-61.13)	0.006
Widowed	5 (0.5%)	--	
Multiple sexual partners in previous 6 months	218 (24%)	1.86 (0.81-4.27)	0.14
Sexual partner has hit, slapped or otherwise physical hurt	32 (4%)	2.77 (0.61-12.58)	0.19
Received HIV test in previous year	209 (23%)	1.35 (0.55-3.27)	0.51
Consistent condom use	110 (16%)	3.56 (1.35-9.39)	0.01
Ever alcohol use	342 (37%)	4.56 (1.88-11.02)	0.001
Ever drug use	114 (12%)	1.37 (0.46-4.06)	0.57
Ever talked about HIV	539 (58%)	1.08 (0.48-2.43)	0.85
Number of lifetime sexual partners			
1-2	285 (31%)	*ref*	
3-4	236 (26%)	0.60 (0.11-3.31)	0.56
5+	404 (44%)	3.47 (1.17-10.30)	0.03
Have main sexual partner	556 (80%)	2.06 (0.47-9.06)	0.34
Live with sexual partner	315 (57%)	1.72 (0.59-5.00)	0.32
Age of first sex			
<18	242 (50%)	*ref*	
≥18	315 (50%)	1.72 (0.59-5.00)	0.87

Classification tree for females

The categorization tree for females is presented in Figure 2. For the CaRT analysis, all eight variables significantly associated with HIV infection, except drug use, were retained. The analysis produced a tree with 23 nodes, including 11 terminal nodes.

Figure 2: Classification tree and risk assessment tool for females



Marital status provided the first split in the tree, which separated widowed women from women of any other marital status. Widowed women had an HIV prevalence of 45%, which signifies being widowed was strongly correlated with being HIV infected. The next split occurred regarding age, and participants aged ≤ 26 years were split from those >27 years. Among younger participants, subsequent splits occurred for number of lifetime sexual partners, testing for HIV within the previous year, and alcohol use. The group reporting no recent HIV test, no lifetime alcohol use, and ≤3 sexual partners had an HIV prevalence of 3.4% (low-risk). The group reporting no recent HIV test, lifetime alcohol use, and ≥2 sexual partners had an HIV prevalence of

15.4% (high-risk). The group reporting no recent HIV test, no lifetime alcohol use, and >3 lifetime sexual partners had an HIV prevalence of 12.1% and was considered high-risk.

Among older participants, groups were further split according to condom use, exposure to intimate partner violence (IPV), marital status, and number of lifetime sexual partners. The HIV prevalence among women reporting IPV and some or no condom use had an HIV prevalence of 28.6% (high-risk). Women who were single, divorced, or separated had an HIV prevalence of 15.9% and were categorized high-risk. For married women reporting two or more lifetime sexual partners, the HIV prevalence was 9.5% (high-risk). Married women reporting one sexual partner had an HIV prevalence of 3.7% and were categorized as low-risk.

Risk profiles of female subjects in all terminal nodes are presented in Table 3a. Of 92 HIV cases, the classification tree correctly categorized 70 as high-risk, which provides a sensitivity of 76.1%. The specificity of the tree was 61.1% with 769 out of 1258 HIV-uninfected cases being correctly classified as low risk.

Table 3a: Mutually exclusive sub-groups identified in CaRT analysis (females)

Terminal Node	Risk profile	N (%) HIV Infected	N (%) HIV Uninfected
LESS RISK			
1	Widowed	9 (45%)[a]	11 (55%)
2	≤26 with 1 lifetime sexual partner	6 (2.2%)	264 (97.8%)
3	≤26 with >1 lifetime sexual partner, HIV test in previous year	4 (2.5%)	157 (97.5%)
6	≤26, no HIV test in previous year, no alcohol use, and ≤3 lifetime sexual partners	4 (3.4%)	113 (96.6%)
7	> 26 reporting "always" condom use	8 (32%)[b]	17 (68%)
10	> 26 reporting "some" or "none" condom use, no IPV, married or married and living separately, and 1 lifetime sexual partner	8 (3.7%)	207 (96.3%)
MORE RISK			
4	≤26 with 2+ lifetime sexual partners, no HIV test in previous year, and alcohol use	6 (15.4%)	33 (84.6%)
5	≤26, no HIV test in previous year, no alcohol use, and >3 lifetime sexual partners	4 (12.1%)	29 (87.9%)
8	> 26 reporting "some" or "none" condom use, and experienced intimate partner violence in previous 6 months	8 (28.6%)	20 (71.4%)
9	> 26 reporting "some" or "none" condom use, no IPV, and divorced, separated or single[c]	21 (15.9%)	111 (84.1%)
11	> 26 reporting "some" or "none" condom use, no IPV, married or married and living separately, and 2+ lifetime sexual partner	31 (9.5%)	296 (90.5%)

[a.] Risk category was changed from high to low risk because the risk assessment tool is designed to be administered to women who test HIV negative. A widowed woman who tests HIV negative is presumably at low risk of infection since her spouse, the potential source of the virus, is no longer present. However, widowed women may still be at risk for HIV infection due to economic vulnerability and traditional practices surrounding the death of a spouse (e.g., widow cleansing). Women in this category will be counseled accordingly.

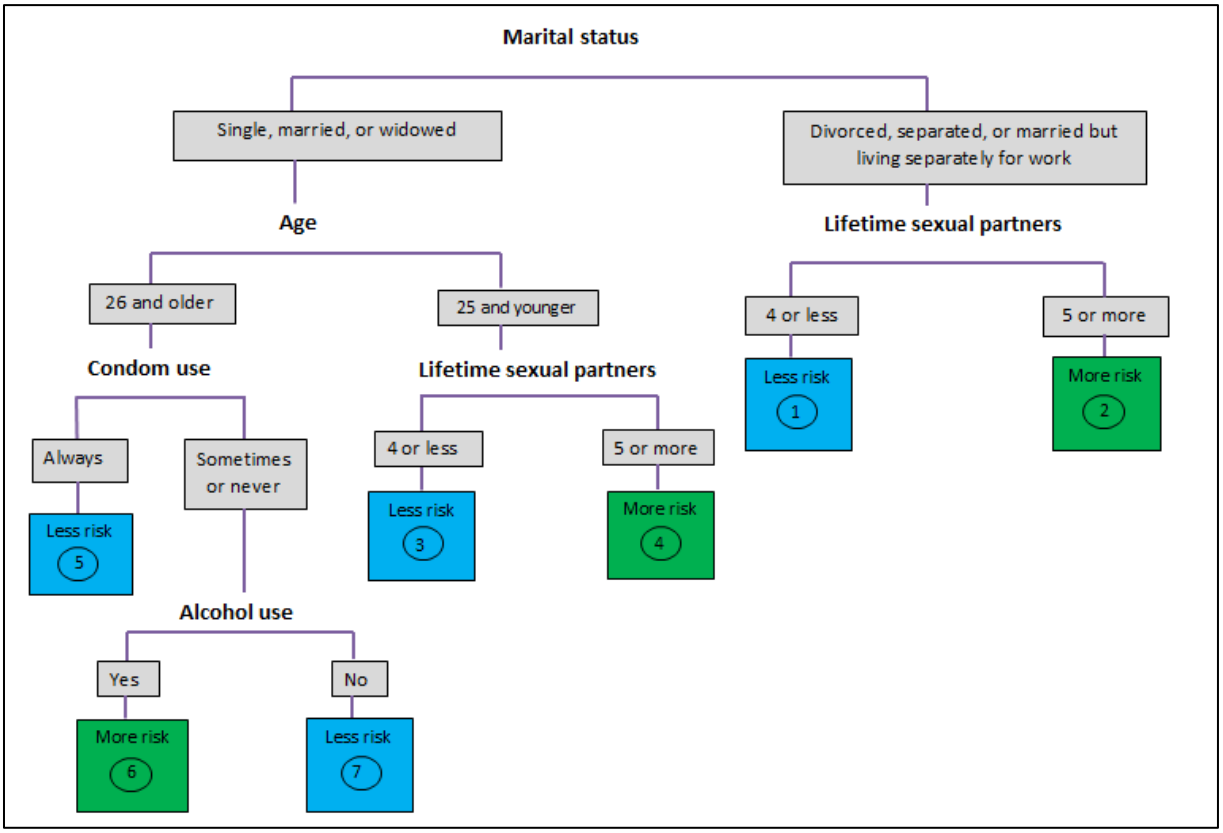
[b.] Risk category was changed from high to low risk due to presumed reverse causation.

[c.] In the original CaRT analysis, this node was split into two child nodes based on alcohol use. Because HIV prevalence among the two child nodes was above 10%, only data from the parent node were used in the final model.

Classification tree for males

CaRT analysis for males retained four of the five variables input into the model and produced a tree with 10 nodes, including 6 terminal nodes. Results are presented in Figure 3.

Figure 3: Classification tree and risk assessment tool for males



For males, the first split occurred with marital status. Among those who were divorced or separated, the tree further split by number of lifetime sexual partners. Those with four or fewer lifetime partners had no HIV infection and were categorized as low-risk. Those with five or more lifetime partners had an HIV prevalence of 21.9% and were categorized as high-risk.

For single, married, or widowed males, the next split occurred with age. Among the younger males aged <25 years, there were only 2 cases of HIV infection (HIV prevalence = 0.5%), so they were initially classified as low-risk, although these were

further sub-divided by number of sexual partners in a subsequent analysis. Among older men reporting some or no condom use and lifetime alcohol use, the HIV prevalence was 4%, and this group was classified as high-risk. Those reporting some or no condom use and no lifetime alcohol use had an HIV prevalence of 1.8% and were classified as low-risk.

Risk profiles and subsequent categorization of all male subjects are presented in Table 3b. The sensitivity of this tree was 71.4% with 15 out of 21 cases of HIV infection correctly categorized as high-risk. The sensitivity was 76.1% with 684 out of 899 true negative cases correctly categorized as low-risk.

Table 3b: Mutually exclusive sub-groups identified in CaRT analysis (males)

Terminal Node	Risk Profile	N (%) HIV Infected	N (%) HIV Uninfected
LESS RISK			
1	Divorced, separated, or married but living separately for work and 1-4 lifetime sexual partners	0 (0)	23 (100)
3, 4	Single/married/widowed, and ≤25 years old[b]	2 (0.5)	416 (99.5)
5	Single/married/widowed, >25 years old, and always condom use	4 (11.8)[a]	30 (88.2)
7	Single/married/widowed, >25 years old, some/never condom use, and no alcohol use	4 (1.8)	215 (98.2)
MORE RISK			
2	Divorced, separated, or married but living separately for work and 5+ lifetime sexual partners	7 (21.9)	25 (78.1)
6	Single/married/widowed, >25, some/never condom use, and alcohol use	8 (4)	190 (96)

[a.] Risk category changed from high to low due to reverse causation.

[b.] There were only two cases of HIV infection among men ≤ 25. When developing the actual risk assessment tool, a proxy outcome for HIV infection, reporting multiple sex partners in the previous 6 months, was selected as an outcome, and a separate CaRT analysis was run to further categorize risk among men aged 25 years or less. In this analysis, young men were categorized as at heightened-risk if they reported five or more lifetime sexual partners and at lower risk if they reported four or less lifetime sexual partners.

Comparison with multivariate logistic regression

Results from the comparison of CaRT and multivariate regression are presented in Tables 4a-4b. For females, all variables retained in CaRT were also retained in the stepwise logistic regression model, with the exception of drug use and condom use. Drug use was not retained in CaRT because it failed to produce sufficient segmentation according to HIV status. In multivariate regression, drug use was associated with HIV infection, odds ratio (OR) = 5.13, although with borderline significance (p=0.13). There were only 5 cases of reported drug use in the female dataset, which could explain why it was not retained in CaRT. Consistent condom use was retained in CaRT but not in stepwise logistic regression. Additionally, the magnitudes of effect of variables in the regression analysis corresponded to the splitting order that occurred in CaRT. For example, the variable with the largest effect, being widowed (OR=10.1, p<0.001) corresponds to the first split in CaRT. The same is true for the second (age), third (number of lifetime sexual partners), and fourth splits (experiencing IPV).

For males, all variables retained in the CaRT analysis, except marital status, were retained in the regression analysis. As marital status was the first split identified in the CaRT analysis, this provides evidence that data were over-fit in CaRT, potentially due to the small number of HIV-infected cases overall (n=25). Receiving an HIV test in the previous year, although associated with HIV infection in bivariate analysis, was not retained in either CaRT or stepwise regression analyses.

Table 4a: Results of multivariate analysis using stepwise selection (for females)

Variables independently associated with HIV status	Retained in CaRT	Retained in regression	OR	p-value
Age	Yes	Yes		
≤26			*ref*	
>26			2.83	<0.0001
Marital status	Yes	Yes		
Single, married, separated, divorced			*ref*	
Widowed			10.1	0.002
Sexual partner has hit, slapped or otherwise physical hurt	Yes	Yes	2.05	0.09
HIV test in previous year	Yes	Yes	0.52	0.016
Consistent condom use	Yes	No	---	
Ever alcohol use	Yes	Yes	1.51	0.14
Ever drug use	No	Yes	5.13	0.12
Number of lifetime partners	Yes	Yes		
1			*ref*	
2+			2.53	0.006

Table 4b: Results of multivariate analysis using stepwise selection (for males)

Variables independently associated with HIV status	Retained in CaRT	Retained in regression	OR	p-value
Age	Yes	Yes		
≤25			*ref*	
>25			3.00	0.10
Marital status	Yes	No		
Single, married or widowed			---	
Married living separately, separated, or divorced			---	
HIV test in previous year	No	No	---	
Consistent condom use	Yes	Yes	4.40	0.004
Ever alcohol use	Yes	Yes	3.61	0.033
Number of lifetime partners	Yes	Yes		
1-4			*ref*	
5+			2.42	0.14

Risk assessment tool development

Deriving the risk assessment tools from the categorization trees took several steps. First, we addressed cases of illogical assignment to high-risk assessment categories. These included instances of contradictory risk categorizations that resulted

from using HIV prevalence, not incidence, as the outcome of interest. In certain cases, this led to presumed reverse causation (i.e., HIV status driving behavior). For example, in both genders consistent condom use was associated with HIV infection, presumably because people were aware of their HIV-positive status and used condoms consistently to protect their sexual partners. For the risk assessment tools, terminal nodes containing subjects reporting consistent condom use were changed from high- to low-risk to reflect actual risk. Among women a similar phenomenon occurred with marital status. Women who were widowed were much more likely to be HIV-infected than women of another marital status. For risk assessment purposes, we determined that if a widowed woman tests HIV negative, she is actually at low risk of becoming infected, since the potential source for infection (her spouse) is no longer present. This category was also changed from high- to low-risk.

Secondly, there were only two cases of HIV-infection among men aged 25 years or younger. However, for risk assessment and triage purposes, it seemed illogical to categorize all young men as at low-risk for HIV infection. As a result, we ran a separate analysis using a behavioral proxy for HIV infection – reporting multiple sexual partners in the previous 6 months – for men aged 25 years or less. The largest predictor of risk from the CaRT analysis using multiple sex partners as the outcome was number of lifetime sexual partners, which was added to the final risk assessment model. This further division increased the sensitivity of the tree from 71.4% to 76.2%.

For females, no additional analyses were conducted, but two terminal nodes were deemed superfluous as HIV prevalence of the parent node and both child nodes was above 12%, meaning that being placed in either child node would result in a high-risk classification. In this case, the parent node was treated as a terminal node to streamline the risk assessment tool.

As a final step, we generated questionnaires for each classification tree to use during the actual categorization process. The risk assessment questionnaire comprised ten yes/no questions for women and six questions for men. The final risk assessment tools created for the Triage Project based on this analysis are presented in Figures 2-3 and corresponding questionnaires in Appendices 1-2.

Discussion

The field of HIV prevention is facing a complex new landscape with increasing prevention options, such as medical male circumcision and PrEP, but stagnant or even decreasing funding for implementation. The recently released strategy for the President's Emergency Plan for AIDS Relief (PEPFAR) 3.0 emphasizes the need "to do the right things in the right places at the right time"[28]. One way this can be accomplished is to identify not only high-risk groups but also high-risk *individuals* in most need of additional prevention services. In this analysis we created risk assessment tools to triage individuals who test HIV-negative but are at heightened risk for HIV infection in order to provide access to additional counseling and partner referral. Although other such categorization efforts are rare, interest is growing. For example, the Partners PrEP study

has developed a simple, clinically-relevant tool to identify HIV-negative members of serodiscordant couples in need of PrEP[9]. One US-based study has examined the feasibility of administering tablet-based risk assessment tools to men who have sex with men (MSM) to improve healthcare providers' awareness about patients' risk behaviors and PrEP potential[29], and one additional study has assessed using risk assessment tools to identify MSM who would benefit from more frequent screenings for sexually transmitted infections[30]. While using such tools has great potential to maximize benefits and reduce costs, it is important to consider the implications and appropriate contexts for applying risk assessment to HIV prevention.

Implications of assessing risk

Through using CaRT analysis, we developed risk assessment tools that were generally successful in categorizing HTC HIV-uninfected clients as at high- or low-risk for HIV infection. Among women and men, the classification trees correctly identified roughly three-quarters of HIV infections. Additionally, the tools used simple questions and a graphical presentation of data to facilitate ease of interpretation and practical use in clinic-based settings. The trees demonstrate satisfactory face and content validity as risks identified through CaRT are consistent with risks previously identified in the literature, including associations between HIV and marital status[31], number of lifetime sexual partners[31, 32], alcohol use[32], and experiencing IPV[33].

What makes this analysis different from most risk assessment tools is its focus on pattern-centric risk categorization as opposed to summative scoring. When developing

clinical decision rules, it is common to derive additive scales and cut-off scores to determine risk level[25]. However, from this analysis it was not clear that risk occurs in a linear or cumulative fashion. Instead, various combinations of variables produced different pictures of risk for different sub-groups of people. For example, what defines risk for a young single female is different from what defines risk for an older married female. Therefore, we deliberately chose not to create an additive scale but instead left the risk assessment tools in decision-tree format, which emphasizes patterns of risk, not a risk threshold.

Within the data, some clear patterns of risk existed, but others were less obvious. In some cases, high-risk groups had seemingly few overt risk factors. For example, over a third of women who were HIV-infected in the Project Accept database were older (≥27 years), married, reported some or no condom use (which is common among married women in Tanzania[34]), had not recently experienced IPV, and reported more than one lifetime sexual partner. Although these women are at heightened-risk of being HIV-infected, they might not consider themselves at risk, nor might this risk be identified using an additive risk score. The implications of this finding are two-fold. First, estimating HIV-related risk is not always straightforward, especially as HIV transmission involves two parties—one of whom may be unaware of the risk behaviors of the other. Secondly, data failing to take into account the behaviors of both sexual partners may omit critical information pertaining to risk. One solution would be to obtain data from both partners, but this would be logistically challenging. Alternatively, surveys could consider adding questions about the behavior of someone's sexual partners. For

example, a study from Jamaica found that asking women whether they thought their main sexual partner had other sexual partners significantly predicted prevalence of sexually transmitted infections[35].

Results from CaRT were mostly concordant with results from logistic stepwise regression. However, although both analyses seek to identify factors relevant to HIV infection, the results they present are not identical in interpretation. CaRT analysis segments subjects into mutually exclusive sub-groups that share a pattern of characteristics related to HIV infection. Regression analysis, on the other hand, measures the *average* association between a variable and HIV infection, holding other variables constant. Previous studies have suggested that segmentation strategies like CaRT, although limited in certain ways, may provide a better means of identifying sub-groups of populations most at risk for certain outcomes[15].

When and where could these tools be used?

Identifying HIV-negative but high-risk clients during HTC and providing these clients with additional services, such as partner referral and additional counseling, has the potential to avert future infections and reduce costs by only providing additional services to those in most need. How much counseling to provide during HTC has become a topic of debate, particularly with the advent of provider initiated testing and counseling (PITC), which provides information but little counseling. Additionally, results from a recent randomized trial, the AWARE trial, found that receiving HIV testing with counseling had no effect on STI incidence as compared to receiving only information[36].

In the US, the CDC recently removed the provision of prevention counseling from their HIV testing guidelines, except for those who test HIV-positive[37], although the World Health Organization recently reiterated counseling as an essential component of HTC[38]. Using risk assessment tools to identify those at high-risk of HIV infection could provide middle ground in the counseling debate in that it could help provide counseling , or additional counseling, only to those who would benefit from it the most.

The cut-off for separating high- from low-risk individuals during risk assessment has significant cost and resource implications. The risk assessment tools created in this analysis will triage about 40% of men and women as at heightened risk for HIV infection. While the tools demonstrate relatively high sensitivity, their specificity is comparatively low, meaning many who are triaged will never become HIV-infected. In part this situation results from using variables associated with individuals who *are* HIV-positive to *predict* HIV infection among HIV-negative individuals, as well as because HIV-infection was a relatively rare outcome among the sample population. However, given the low costs of providing additional counseling and partner referral to high-risk participants, the voluntary nature of accessing the additional services, and the minimal harm in being misclassified in the Triage Project, risk assessment under these conditions was considered feasible. Other situations where broad triaging may be acceptable include partner notification interventions and other programs focused on recruiting partners of high-risk individuals for testing. However, if intervention costs were higher and harms of misclassification were greater, triaging might not be cost-effective or ethical. For

example, assessing risk for potential PrEP users would require a higher threshold of risk to receive the intervention give the cost of PrEP and potential harms.

Limitations

Findings from this study must be seen in light of several limitations. The analyses used HIV status (infected vs. not infected) as the basis for building the risk assessment tools, which limited the ability to infer causation of HIV status from the independent variables. In fact, evidence of reverse causation was seen in the data where protective risk behaviors, e.g., consistent condom use, were significantly associated with being HIV infected. All behavioral data in this study were self-reported, so social-desirability bias could have influenced responses. Additionally, CaRT analysis, while being simple and easy to interpret, is not able to control for confounders, and small changes in data can affect the cut-points and splits of the categorization tree. The relatively small number of HIV cases, particularly among males (n=25), also limited the analysis. Although patterns between variables and HIV infection were clearly seen, a larger sample size would have improved the ability to tease out patterns of risk. Additionally, although steps were taken to internally validate the risk assessment tools, they have not been externally validated. Finally, one of the strengths and limitations of this analysis is that it is highly context dependent. The strength of using data from Kisarawe is that it enabled us to create a more accurate risk assessment tool for this setting and the Triage Project. The downside is that these risk assessment tools are unlikely to be directly transferrable to other epidemic settings. However, the methods used to create the risk assessment tools

could easily be adapted to other study locations if sufficient data were available. Given the simplicity of questions used to create the tools, program planners could potentially use large, country-wide datasets, such as Demographic and Health Survey data, to create such tools.

Conclusion

Previous literature has recommended that HIV prevention projects include components targeting the general population, such as providing mass media campaigns about safe behaviors, *and* components targeting specific individuals/groups at heightened risk of HIV infection, which can be especially important in areas with high HIV prevalence[39]. Finding effective means of targeting high-risk individuals, beyond traditional considerations of key populations (e.g., sex workers, injection drug users, and MSM), could have important implications for HIV prevention in generalized epidemic settings.

Additionally, in an era of reduced funding for HIV prevention, maximizing the efficacy of existing interventions remains of paramount importance. If PEPFAR's 3.0 vision of strategic investment and targeting is to be successful, we must develop ways to identify those in most need of services. This analysis presented the development of risk assessment tools that will be used to triage clients during HTC to provide those at high-risk access to additional services, including incentivized additional counseling and partner referral. The resulting tools comprise decision trees that are easy to interpret and questionnaires that consist of simple yes/no questions that can be administered by

a nurse counselor during HTC. However, applications for this type of tool extend far beyond their use in the Triage Project. Risk assessment for HIV prevention could be used to identify those in need of PrEP, medical male circumcision, partner notification/referral, counseling, STI screening, and many other interventions. In regards to HTC, risk assessment provides an opportunity to enhance the preventative benefits for those who are HIV-uninfected but at high-risk of becoming infected, which so far has been a neglected population.

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MANUSCRIPT 3:

DO SEXUAL PARTNERS TALK TO EACH OTHER ABOUT HIV? EXPLORING THE ROLE OF GENDER AND POWER IN PARTNER COMMUNICATION ABOUT HIV IN KISARAWE, TANZANIA

Abstract

Background: The dyadic nature of HIV prevention receives inadequate attention within interventions**.** Partner communication about HIV is one important dyadic factor that could lead to behavior change, including increased condom use and HIV testing. This study sought to understand factors related to partner communication using constructs from the Theory of Gender and Power.

Methods: We used cross-sectional data from a random sample of men and women aged 18-55 years living in Kisarawe, Tanzania reporting at least one sexual partner in the past 6 months. Bivariate and multivariate logistic regression analysis were used to build models containing factors associated with partner communication about HIV transmission relating to the sexual division of labor, power and cathexis.

Results: Of 550 included participants, 137 women (44.0%) and 102 men (44.3%) reported prior communication about HIV transmission with their most recent sexual partner. In multivariate analyses, prior communication about HIV for women was positively correlated with radio ownership and inversely associated with having high levels of discrimination towards people living with HIV. For men, reporting some condom use and having a young sexual partner (<25 years) was inversely associated with partner communication. Across both men and women, having favorable social norms toward HIV prevention, progressive gender norms, and participating in at least one social group were significantly correlated with partner communication.

Conclusions: Predictors of partner communication vary by gender. Partner communication is influenced by social-level factors, including social norms related to HIV prevention, gender norms, and social participation. Therefore, community-level interventions to change norms could also change communication patterns among dyads. Developing gender-specific HIV testing strategies could help increase uptake for men and women.

Background

Sexual transmission of HIV, which accounts for the majority of HIV infections worldwide[1], involves two individuals—one person infected with HIV and the other not infected. Despite this obvious fact, the dyadic nature of HIV transmission and HIV prevention is often overlooked[2]. HIV prevention efforts have mainly focused on the individual level and used individual-level theories to explain behavior, ignoring relevant relational, social, and structural factors[3, 4]. In a framework conveying the central importance of dyads in HIV prevention, Karney and colleagues specify that enacting safer sexual behavior depends on sexual dyads acting in coordination to achieve a desired purpose[2]. Communication about HIV-related risk between sexual partners, whether verbal or non-verbal, implicit or explicit, is necessary for establishing coordination between partners for HIV prevention. However, limited research exists on what factors are related to partner communication and how this affects HIV prevention.

Communication and HIV

Communication about HIV can involve an exchange of information about HIV as a social issue (e.g., "HIV is a problem in this community") or as a personal and interpersonal issue (e.g., "I am worried about becoming infected with HIV"). As a social issue, having any conversations about HIV has been associated with positive HIV-related behaviors, such as prior HIV testing[5,6]. An ecological study from Uganda suggests that communication about HIV within social networks helped change HIV-related risk behaviors and lowered HIV incidence[7]. Interpersonal communication about HIV within

social networks has also been associated with lower levels of stigma and higher levels of HIV-related knowledge[8].

On an interpersonal level, HIV risk communication with sexual partners, such as talking about prevention, agreeing to use condoms during sex, discussing HIV testing, and serostatus disclosure, can serve as a precursor to behavioral change. Studies have linked risk communication between sexual partners to increased HIV testing[9, 10] and condom use[3, 11-13]. However, most research about HIV-related communication within sexual partnerships has focused on disclosure of HIV serostatus, not communication about risk. Research suggests that barriers to disclosure, such as fear of rejection, violence, and accusations of infidelity[14], may also prevent women from discussing HIV-related risk[15].

Communication as a gendered occurrence

Previous research demonstrates that factors affecting partner communication about HIV include structural drivers such as education and wealth, but these affect communication differently by gender[16]. A cross-sectional study from South Africa found that partner communication among women was associated with factors such as educational level, number of sexual partners, occupation of male partner, and age differential between partners[17]. Taken together, this research suggests that factors related to communication differ for men and women.

Gender inequity is pervasive in Tanzania[18-20]. Due to a combination of biological, social, and structural differences between genders, women in Tanzania have a higher

HIV prevalence than men. While this difference holds across all age groups, it is especially marked in younger age groups; HIV prevalence among women aged 25-29 years is 7.0% as compared to 2.5% among men of the same age[21]. Several studies have linked HIV-related risk to gender power imbalances in sub-Saharan Africa, including Tanzania[22, 23]. Women's constrained power and agency can lead to risk factors related to HIV, including lower socio-economic status[24], intimate partner violence, coerced sex, and sexual abuse[22, 23], and experiencing conflicting sexual norms and expectations that simultaneously promote male sexual promiscuity and female sexual restraint[19].

Several studies have found that women's' reduced access to social and material resources and reduced power in intimate relationships inhibit partner communication about HIV-related risk[18, 25]. A study from Kenya found that partner communication about HIV was low, in part due to lack of knowledge and understanding of HIV transmission among women but not men,[26] suggesting women had less access to educational resources. Several studies from Malawi have shown that women have a difficult time discussing HIV risk and condom use with partners because asking a partner to use a condom was akin to acknowledging a lack of trust and fidelity in the relationship[27, 28]. A qualitative study from Tanzania found that among young people, gender norms regulate who can initiate a conversation about sexual risk as participants acknowledged it was inappropriate for females to talk about sex and sexuality[29].

Theory of Gender and Power

Connell's Theory of Gender and Power posits that cultural and social differences between men and women are driven by three main dimensions: 1) sexual division of

labor, 2) sexual division of power, and 3) cathexis, which is a term used to describe the social norms and expectations of men and women[30]. As described by Wingood et al.[31], the sexual division of labor refers to the different occupational norms of men and women and the devaluation of occupations typically performed by women, including child rearing. Over time this leads to a gender gap in income and socio-economic status, which adversely affects women by inhibiting education and employment options, thus affecting subsequent health-related outcomes, including HIV-related risk[31]. Additionally, the sexual division of labor can lead to women engaging in sexual relationships at a young age or with an older sexual partner due to economic necessity[32, 33], which also creates power imbalances. The sexual division of power reflects the ability of one individual or group of individuals to influence or change others, i.e., "having power over others"[31]. Operationally, the sexual division of power can be measured through exposure to gender-related violence, including intimate partner violence, sexual abuse, physical abuse, and coercive sex[22, 23]. Additionally, power imbalances can be manifested in behavioral risk factors, such as drug and alcohol use and multiple sexual partners, as these behaviors indicate potential powerlessness or a lack of perceived control over behaviors or situations leading to unhealthy behaviors[31]. Cathexis involves the social expectations of women and men and how sexuality is attached to other social ideas, such as immorality[31]. Social norms surrounding a women's role as passive in a sexual relationship can prevent her from speaking up about HIV-related risk. Additionally, exposure to and engagement in social groups may shape these norms and influence risk behavior[34].

The Theory of Gender and Power has been used to examine HIV-related risk among women in several different settings, including developed[31, 35] and developing countries, such as Tanzania[20]. However, little research has been conducted among men using constructs from this theory. We hypothesize that because communication is a gendered occurrence, variables related to the Theory of Gender and Power will influence women's communication with male sexual partners, as well as men's communication with female sexual partners about HIV-related risk, although in different, contrasting ways. Therefore, the aim of this analysis was to examine how variables from the Theory of Gender and Power predict partner communication about HIV among women and men using a sample of sexually-active adults residing within a rural district in Tanzania.

Methods

Data collection

This study involved cross-sectional data collected from individuals residing in Kisarawe district, Tanzania from October 2013 to June 2014 as part of the baseline assessment for the Triage Project, a phase II community-randomized trial assessing the effectiveness of a community-based HIV prevention intervention on reducing STI incidence. A two-stage sampling strategy was employed with random selection taking place at both the household- and individual-level. Households within 10 villages were randomly selected for participation following enumeration of all households using GPS mapping. After obtaining written informed consent, a trained interviewer collected information from the head of household on socio-demographics, household assets, and

enumerated all individuals living within the household. Within each household one eligible household member was randomly selected to participate in an in-depth behavioral survey and biological assessment. In order to contact the selected participant, households were visited up to three times. If the potential participant could not be located after three visits, no substitutions were made.

To be eligible for participation, individuals had to be between 18-55 years of age, living full-time in the household with plans to live there for at least 2 years, and provide written informed consent. Participants were explained the study objectives, all studies procedures, and were assured their responses would be kept confidential. Participants were reimbursed for their time with 1kg bags of uncooked rice and beans. Interviews were conducted face-to-face in Kiswahili in a private area of the participant's choosing in or near the household. Data were collected on electronic tablets (Samsung Tab 2) and sent to a secure server. The study was approved and granted ethical clearance by the Medical University of South Carolina and the Muhimbili University of Health and Allied Science in Dar es Salaam, Tanzania.

In addition to completing a behavioral survey, participants were screened for HIV using two parallel rapid tests, Determine HIV 1/2 and Unigold HIV 1/2 rapid test performed onsite. Blood specimens from all reactive results and 10% of unreactive results were confirmed using lab-based assays. A result was considered "HIV positive" if results from the field-based and lab-based testing confirmed the presence of HIV antibodies. All participants received pre- and post-test counseling by trained counselors

and were referred to the rural health clinic for treatment if warranted. Participants were free to refuse HIV testing or opt-out of learning their test results.

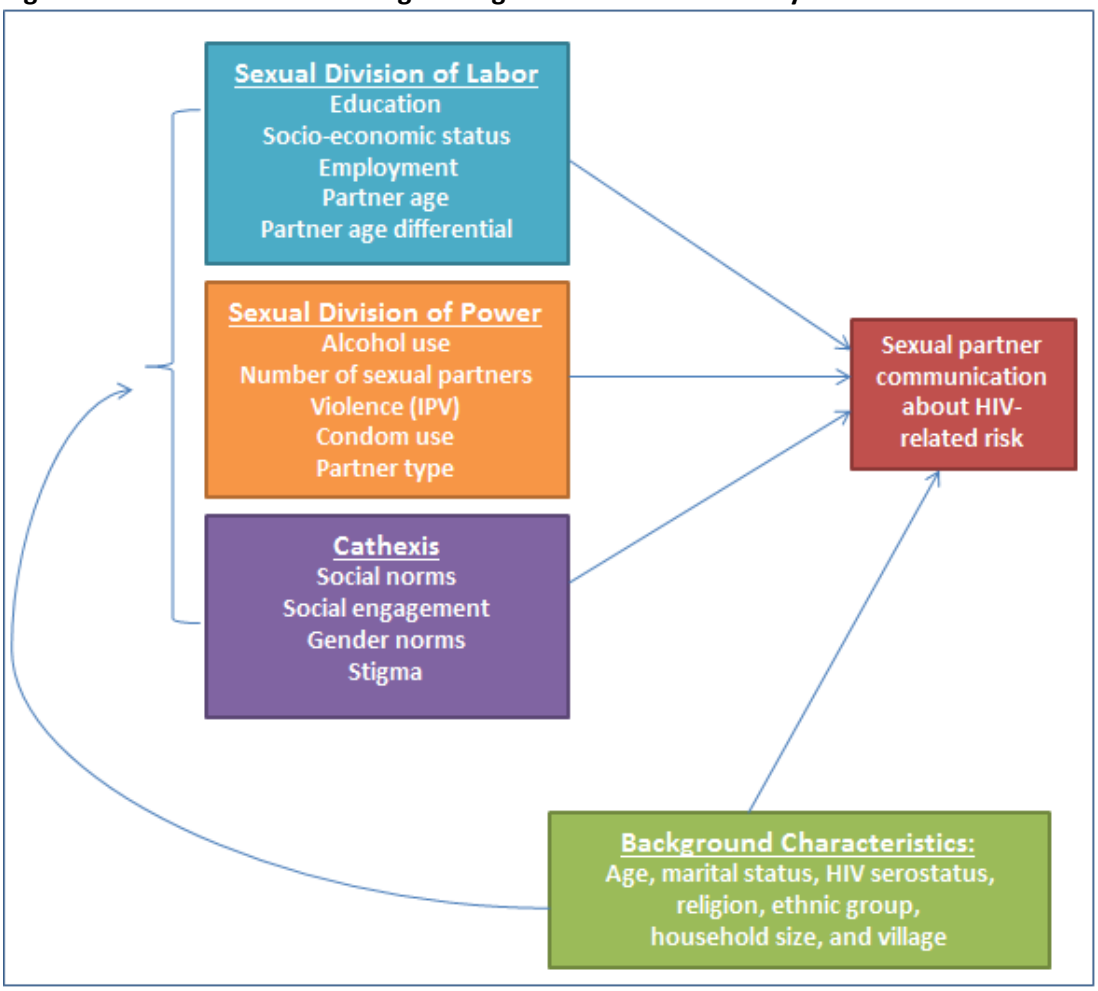
Variable selection and measures

The outcome variable used in this analysis was partner communication about HIV transmission. This was measured among participants who reported at least one sexual partner in the last 6 months using the following question: "Have you ever talked with this partner about the possibility of transmitting HIV?" Participants who reported being sexually active were asked this and other partner-specific questions for up to four of their recent sexual partners. We restricted this analysis to partner communication about HIV transmission with the participant's most recent sexual partner.

To ascertain predictors of partner communication, we selected variables *a priori* for inclusion in the analysis based on constructs from the Theory of Gender and Power. These variables are presented in Figure 1. Within the sexual division of labor, we included employment status, educational attainment, socioeconomic status (SES), partner age ("young" partners defined as ≤25 years old), and partner age differential. Partner age differential was dichotomized at < 10 years and ≥10 years as intergenerational sex is usually defined as sexual relationships with a 10 or more year disparity between partners[36]. Household possession of a radio was used a proxy for SES, which has previously been used as a measure for both SES and access to mass media[37]. Within the sexual division of power, we included lifetime use of alcohol, frequency of condom use in the past 6 months, number of sexual partners in the past 6 months, and

experience of physical intimate partner violence (IPV) (assessed by asking: “in the past year have you had a sexual partner that has hit, slapped, kicked, pushed, shoved or otherwise physically hurt you?”). IPV was the only variable within the list of candidate predictors that was assessed differently for males and females. For females we included experiencing IPV whereas for males we included IPV perpetration, because although both males and females can experience IPV, women experience IPV at much higher rates, mostly at the hands of male partners[38]. We also included the type of partner (spouse, boyfriend/girlfriend, or casual partner) as this dyadic characteristic was hypothesized to contribute to power differentials within relationships. Within the construct of cathexis, we included social norms related to HIV prevention, social engagement, HIV-related stigma, and gender norms relevant to the Theory of Gender and Power.

Figure 1. Variables included in logistic regression based on Theory of Gender and Power



Several latent constructs were included as variables, including social norms about HIV prevention, stigma, and gender norms. These constructs were mostly measured using multiple items adapted from previously validated scales. For social norms relating to HIV prevention, items were adapted from surveys used in Project Accept to assess norms surrounding HIV testing[5, 39] and new items were created relating to discussing HIV with sexual partners and condom use. Items were assessed for unidimensionality using exploratory factor analysis and internal consistency using

Cronbach's alpha (α=0.71). The scale was dichotomized at the median with high scores representing "favorable" norms toward HIV prevention and low scores as "unfavorable". For social participation, we created an index based on participants' reported engagement in any of the following organizations: religious, social (e.g., women's group), work-related (e.g., agricultural coop), or savings/lending groups. We dichotomized the index to "some" social engagement if participants reported being a member of any of these groups or "no" social engagement if participants reported no group membership.

For stigma, we analyzed three types of stigma—anticipated stigma, perceived stigma, and experienced stigma/discrimination based on recent work done by the Global Stigma and Discrimination Indicator Working Group[40, 41]. Anticipated stigma reflects fear of negative consequences if one's HIV-positive status becomes known, perceived stigma reflects the perception of stigma toward people living with HIV by community members, and experienced stigma and discrimination reflects different treatment of someone living with HIV both within and outside the purview of law[41]. Scale items were assessed using exploratory factor analysis and Cronbach's alpha (α=0.75 for perceived stigma; α=0.80 for discrimination). Scores were summed and dichotomized at the median. For gender norms, questions were adapted from a series of items measuring attitudes towards women's human rights and roles in society[42, 43] to align with the constructs within the Theory of Gender and Power, specifically the sexual division of labor ("Women should be allowed to work outside the home") and the division of power ("Women's wishes should be taken into account when making

decisions for the home"). The items were analyzed separately and dichotomized as "progressive" for those agreeing or strongly agreeing and "traditional" for those disagreeing or strongly disagreeing with each statement. Details of items included in variable construction are included in Appendix 2.

Analysis

Given the hypothesis that gender inequality affects partner communication, separate regression models were constructed for men and women. The analysis was restricted to participants who reported having at least one sexual partner in the previous six months as variables of interest concerned recent partner characteristics. Participants living with HIV who reported being previously aware of their serostatus (n=22) were also excluded from the analysis as communication about HIV in these cases was most likely linked to disclosure of HIV status, not communication about risk.

Pearson chi-squared tests were used to assess gender differences among variables identified as potential confounders, including age, marital status, religion, and ethnic group. We first analyzed data descriptively by cross-tabulating partner communication and candidate variables, and bivariate logistic regression analyses were run to assess associations between partner communication and all variables in the model. We constructed multivariate logistic regression models for each gender using all variables associated with partner communication at $p<=0.10$ in bivariate analysis plus potential confounders identified *a priori*, including age, marital status, religion, and ethnic group. Several variables related to study design, including household size and

village where participants' resided, were also controlled for in multivariate analysis. Backwards stepwise selection (p=0.10 for removal from the model) was used for final model selection. Potential confounders and variables related to the study design were locked into the model and not subjected to the stepwise procedure. Results of the stepwise selection were compared to results from simultaneously entering all variables in the model, which produced similar results for each gender. We also assessed for collinearity by evaluating variance inflation factors produced by each factor in the model and tested for interactions between independent variables.

Results

Of 740 participants who completed the behavioral survey, 550 reported being sexually active and having at least one sexual partner in the past 6 months and were included in the analysis. Of these, 237 (43%) were male and 313 (57%) were female. The mean age for men was 38 (SD=10.6) years and 35 (SD=10.33) years for women. The sample population was predominantly Muslim (84%), but there was a larger proportion of Christians among females (22%) as compared to males (12%). Additionally the sample was predominantly of the Zaramo ethnic group (65%), although a significant proportion of participants (35%) reported belonging to other ethnic groups found within Tanzania. Almost half of participants (43.8%) reported ever communicating about HIV transmission with their most recent sexual partner. Rates of communication did not differ between males and females (p=0.29). About one quarter of the sample (n=133) reported being single/never married, 69% were married (n=379), and 7% (n=38)

reported being divorced, widowed, or separated. Marital status of participants was similar across genders. HIV prevalence among the sample was 9.7% overall with no significant difference by gender. Sample characteristics are presented in Table 1.

Table 1. Sample characteristics of sexually active men and women reporting at least one sexual partner in the past 6 months (n=550)

Variable	Total N (%)	Female N (%)	Male N (%)	p-value
Gender				
Female	237 (43.1)	--	--	--
Male	313 (56.9)	--	--	
Communication with sexual partner	307 (56.2)	174 (56.0)	133 (56.6)	0.88
No	239 (43.8)	137 (44.0)	102 (43.4)	
Yes				
Age				
(mean, SD)	*(36.0, 10.6)*	*(34.6 , 10.33)*	*(38.0, 10.6)*	
18-25	114 (20.7)	77 (24.6)	37 (15.6)	<0.01
26-35	159 (28.9)	99 (31.6)	60 (25.3)	
36-45	158 (28.7)	78 (24.9)	90 (33.8)	
46+	119 (21.6)	59 (18.9)	60 (25.3)	
Marital status				
Single	133 (24.2)	70 (22.4)	63 (26.6)	0.29
Married	379 (68.9)	224 (71.6)	155 (65.4)	
Divorced, widowed, separated	38 (6.9)	19 (6.1)	19 (8.0)	
HIV status				
Negative	475 (90.3)	272 (90.1)	203 (90.6)	0.83
Positive	51 (9.7)	30 (9.9)	21 (9.4)	
Religion				
Muslim	463 (84.2)	276 (88.2)	187 (78.9)	<0.01
Christian	87 (15.8)	37 (11.8)	50 (21.1)	
Ethnic group				
Zaramo	357 (64.9)	214 (68.4)	143 (60.0)	0.05
Other	193 (35.1)	99 (31.6)	94 (40.0)	

Patterns of communication for all candidate variables and results from bivariate logistic regression are presented in Table 2 for women and Table 3 for men. Regarding labor-related variables, approximately 86% of men and women reported being self-employed farmers or venders. Only 9.2% of men and 3.7% of women were employed

with a fixed salary. Approximately 70% of men and women reported attaining a primary education (standard 1-7); 12.7% of men and 9.3% of women went to secondary school or received post-secondary education. Men were on average 7.1 years older than their most recent sexual partner and women were on average 7.7 years younger than their most recent partner. Additionally, 37.1% of men reported having a partner that was aged 25 years or less compared to 12.1% of women.

Within the sexual division of labor, the percentage of women who reported communicating with their partner about HIV increased as educational attainment increased, as 36% reporting communication with no education, 43% with a primary education, and 61.5% with a secondary education or higher. Women who lived in households that had a radio were more likely to communicate with their partners compared to women without a radio. Women who were employed with a fixed salary or paid on a daily-basis had over 5 times the odds of partner communication as compared to women who were self-employed farmers or vendors; however, only 3.7% of women reported having this type of employment. Having a partner age differential of ten years or greater was not associated with partner communication for men or women. Among men, no variables related to the division of labor were significantly associated with partner communication in bivariate analysis except for having a sexual partner aged 25 years or younger, which was inversely associated with communication. HIV status was associated with partner communication for women, with HIV-positive women reporting less communication than HIV-negative women (excluding HIV-positive participants who

were aware of their serostatus prior to the assessment). This association trended in the same direction for men as well.

Regarding the sexual division of power, 28.5% of men reported having more than one sexual partner in the past 6 months whereas only 11.3% of women reported multiple partners within the same timeframe. Seventy-nine percent of women and 68% of men reported never using condoms in the past 6 months. Eight percent of women reported experiencing physical IPV from a sexual partner in the past year and 4% of men reported perpetrating IPV against a sexual partner. Regarding partner communication, there was no association between communication and lifetime alcohol use and condom use for women. For men, condom use was inversely associated with communication whereas lifetime alcohol use was positively associated with communication in bivariate analysis. Experiencing IPV trended toward significance ($p=0.08$) as women who reported experiencing violence reported more communication with partners than women who did not experience violence. Perpetration of violence was not significantly associated with partner communication for men. Having multiple partners was inversely associated with partner communication for women, but showed no association for men. Odds of communication were higher when the most recent sexual partner was a spouse as compared to a boyfriend or casual partner for both men and women.

For variables related to cathexis, women and men who reported favorable social norms related to HIV prevention reported higher rates of communication (51% for men and 53% for women) than those with unfavorable social norms (33% for men and 38%

for women). Similarly, reporting some social engagement was correlated with more partner communication as compared to no social engagement for both men and women. For the gender norm related to women being allowed to work outside the home, agreement with this statement was high among men (88.6% agreed) and women (84.6%) and was associated with communication with sexual partners for both men and women. For the gender norm relating to women's wishes being taken into account when making household decisions, agreement was high for men (88.6%) and women (87.4%). Regarding stigma, anticipated stigma was not associated with communication for either gender. Perceived stigma was associated with communication for men but not for women. Discrimination/experienced stigma were associated inversely with communication for women but not men.

Table 2. Bivariate associations with partner communication among variables related to the Theory of Gender and Power for women

	Variable	Total (N, %)	% Reporting HIV communication with partner	OR (95% CI)	p-value
Division of Labor	**Education**[f]				
	No education	61 (20.3)	22 (36.1)	*Ref*	
	Primary school	211 (70.3)	91 (43.1)	1.34 (0.75-2.42)	0.33
	Secondary school and above	28 (9.3)	16 (61.5)	2.84 (1.10-7.31)	0.03
	Possession of radio[f]				
	No	113 (37.8)	37 (33.0)	*Ref*	
	Yes	186 (62.2)	92 (49.7)	2.00 (1.23-3.27)	<0.01
	Employment[f]				
	Self-employed	254 (84.7)	106 (41.9)	*Ref*	
	Employed (fixed salary)	11 (3.7)	8 (80.0)	5.55 (1.15-26.65)	0.03
	Not employed	35 (11.7)	15 (42.9)	1.04 (0.51-2.12)	0.91
	Partner age difference				
	<10	187 (62.3)	82 (44.3)	*Ref*	
	≥10	113 (37.7)	47 (41.6)	0.89 (0.56-1.44)	0.64
	Age of partner[f]				
	≤25	38 (12.7)	11 (28.9)	0.49 (0.23-1.03)	
	>25	262 (87.3)	118 (45.4)	*Ref*	0.06
Division of Power	**Alcohol use in lifetime**				
	No	205 (68.3)	90 (44.3)	*Ref*	
	Yes	95 (31.7)	39 (41.2)	0.87 (0.54-1.43)	0.60
	Number of sexual partners in past 6 months[f]				
	1	266 (88.7)	119 (44.9)	*Ref*	
	>1	34 (11.3)	10 (30.3)	0.53 (0.24-1.16)	0.11

	Condom use in the past 6 months				
	None	236 (79.2)	104 (44.1)	*Ref*	0.74
	Rarely/sometimes/always	62 (20.8)	25 (41.7)	0.91 (0.51-1.61)	
	Experiencing physical intimate partner violence[ʃ]				
	No	275 (91.7)	114 (41.8)	*Ref*	
	Yes	25 (8.3)	15 (60.0)	2.09 (0.91-4.82)	0.08
	Partner type[ʃ]				
	Spouse	218 (73.2)	103 (47.5)	1.84 (1.07-3.16)	0.03
	Boyfriend or casual partner	80 (26.8)	26 (32.9)	*Ref*	
Cathexis	**Social norms on HIV prevention[ʃ]**				
	Unfavorable	87 (34.5)	26 (30.2)	*Ref*	
	Favorable	165 (65.5)	84 (51.2)	2.42 (1.39-4.21)	<0.01
	Social engagement[ʃ]				
	No participation	129 (43.1)	46 (35.7)	*Ref*	
	Some participation	170 (56.9)	83 (49.4)	1.69 (1.07-2.66)	0.02
	Stigma-Anticipated stigma				
	Low	103 (35.2)	46 (44.2)	*Ref*	
	High	190 (64.9)	89 (44.5)	0.97 (0.60-1.58)	0.90
	Stigma-Perceived stigma				
	Low	99 (33.5)	39 (39.8)	*Ref*	
	High	197 (66.5)	90 (45.9)	1.28 (0.78-2.10)	0.32
	Stigma-Discrimination/experienced stigma[ʃ]				
	Low	194 (68.9)	98 (50.8)	*Ref*	
	High	105 (35.1)	31 (29.8)	0.41 (0.25-0.68)	<0.01
	Gender norm: Women allowed to work[ʃ]				
	Disagree	47 (15.7)	14 (30.4)	*Ref*	
	Agree	252 (84.3)	115 (45.8)	1.93 (0.98-3.80)	0.06
	Gender norm: Women's decision-making[ʃ]				
	Disagree	37 (12.5)	10 (27.8)	*Ref*	
	Agree	260 (87.5)	119 (46.0)	2.21 (1.02-4.77)	0.04
Other	Age				
	18-25	76 (25.3)	29 (39.2)	*Ref*	
	26-35	94 (313)	50 (53.2)	1.76 (0.95-3.27)	0.07
	36-45	73 (24.3)	29 (39.7)	1.03 (0.53-1.98)	0.95
	46+	57 (19.00)	21 (36.8)	0.90 (0.44-1.85)	0.78
	Marital status				
	Single	67 (22.3)	21 (31.8)	*Ref*	
	Ever married	233 (77.7)	108 (46.6)	1.87 (1.05-3.33)	0.04
	HIV status				
	Negative	272 (93.5)	124 (45.8)	*Ref*	0.03
	Positive[ᵗ]	19 (6.5)	3 (16.7)	0.24 (0.07-0.84	

[ʃ] Significant in bivariate analysis (p<=0.10) and retained in multivariate regression

[ᵗ] Restricted to HIV positive participants who were unaware of their serostatus as time of survey completion.

Table 3. Bivariate associations with partner communication among variables related to the Theory of Gender and Power for men

	Variable	Total N (%)	% Reporting HIV communication with partner	OR (95% CI)	p-value
Division of Labor	**Education**				
	No education	30 (13.2)	11 (36.7)	*Ref*	
	Primary	169 (74.1)	71 (42.5)	1.28 (0.57-2.85)	0.55
	Secondary school or above	29 (12.7)	14 (48.3)	1.61 (0.57-4.56)	0.37
	Possession of radio				
	No	59 (26.0)	23 (39.0)	*Ref*	
	Yes	168 (74.0)	72 (43.4)	1.20 (0.65-2.20)	0.56

	Employment				
	Self-employed	199 (87.3)	83 (42.1)	*Ref*	
	Employed (fixed salary)	21 (9.2)	11 (52.4)	1.51 (0.61-3.72)	0.37
	Not employed	8 (3.5)	2 (25.0)	0.46 (0.09-2.32)	0.35
	Age difference				
	<10	144 (63.2)	61 (43.0)	*Ref*	
	≥10	84 (36.8)	35 (41.7)	0.95 (0.55-1.64)	0.85
	Age of partner[ſ]				
	≤25	86 (37.7)	25 (29.1)	0.40 (0.22-0.71)	
	>25	142 (62.3)	71 (50.7)	*Ref*	<0.01
Division of Power	**Alcohol use in lifetime[ſ]**				
	No	97 (42.5)	34 (35.4)	*Ref*	
	Yes	131 (57.6)	62 (47.7)	1.66 (0.97-2.86)	0.07
	Number of sexual partners in past 6 months				
	1	163 (71.5)	69 (42.6)	*Ref*	
	>1	65 (28.5)	27 (42.2)	0.98 (0.56-1.76)	0.96
	Condom use[ſ]				
	None	155 (68.0)	71 (46.4)	*Ref*	
	Rarely/sometimes/always	73 (32.0)	25 (34.3)	0.60 (0.34-1.07)	0.08
	Perpetrating physical intimate partner violence				
	No	218 (96.0)	93 (43.1)	*Ref*	
	Yes	9 (4.0)	3 (33.3)	0.66 (0.16-2.71)	0.57
	Partner type[ſ]				
	Spouse	142 (62.6)	68 (48.2)	1.86 (1.07-3.26)	0.03
	Boyfriend/casual	85 (37.4)	28 (33.3)	*Ref*	
Cathexis	**Social norms on HIV prevention[ſ]**				
	Unfavorable	63 (31.0)	20 (32.3)	*Ref*	
	Favorable	140 (69.0)	69 (49.6)	2.07 (1.10-3.88)	0.02
	Social engagement[ſ]				
	No participation	74 (32.5)	24 (32.4)	*Ref*	
	Some participation	154 (67.5)	72 (47.4)	1.76 (1.10-2.82)	0.02
	Stigma-Anticipated stigma				
	Low	82 (36.4)	32 (38.5)	*Ref*	
	High	143 (63.6)	70 (47.0)	1.41 (0.81-2.45)	0.23
	Stigma-Perceived stigma[ſ]				
	Low	79 (34.6)	26 (32.9)	*Ref*	
	High	149 (65.3)	70 (47.6)	1.85 (1.05-3.28)	0.03
	Stigma-Discrimination/experienced stigma				
	Low	147 (64.5)	65 (44.8)	*Ref*	
	High	81 (35.5)	31 (38.3)	0.76 (0.43-1.33)	0.34
	Gender norm: Women allowed to work[ſ]				
	Disagree	38 (16.7)	6 (15.8)	*Ref*	
	Agree	190 (83.3)	90 (47.9)	4.90 (1.96-12.26)	<0.01
	Gender norm: Women's decision-making[ſ]				
	Disagree	27 (11.9)	9 (33.3)	*Ref*	
	Agree	200 (88.1)	87 (43.9)	1.57 (0.67-3.66)	0.30
Other	Age				
	18-25	36 (15.8)	9 (25.7)	*Ref*	
	26-35	59 (25.8)	21 (36.2)	1.64 (0.65-4.15)	0.30
	36-45	76 (33.3)	39 (51.3)	3.05 (1.26-7.35)	0.02
	46+	57 (25.0)	27 (47.4)	2.60 (1.04-6.52)	0.04
	Marital status				
	Single	60 (26.3)	20 (33.9)	*Ref*	
	Ever married	168 (73.7)	76 (45.5)	1.63 (0.88-3.02)	0.12
	HIV status				
	Negative	203 (93.5)	89 (44.3)	*Ref*	
	Positive[ᵠ]	14 (6.5)	3 (21.4)	0.34 (0.10-1.27)	0.11

[ſ] Significant in bivariate analysis (p<=0.1) and retained in multivariate regression

ᵗ Restricted to HIV positive participants who were unaware of their serostatus as time of survey completion.

In multivariate analysis, the final regression model for women contained six variables: radio ownership, having high levels of discrimination/experienced stigma, having favorable social norms toward HIV prevention, participating in at least one social group, being married, and agreement with both gender norm statements relating to women working outside the home and taking women's wishes into account when making household decisions. Women reporting high levels of discrimination were less likely to communication with their partner about HIV as compared to women reporting one recent sexual partner and women with low levels of discrimination/experienced stigma. Having favorable social norms toward HIV prevention, progressive views of gender norms, some social participation, and radio ownership were all positively associated with partner communication. An interaction term between social and gender norms trended toward significant (p=0.09) for the gender norm related to taking women's wishes into account with household decision-making and social norms related to HIV prevention. Results from the multivariate regression are presented in Table 4.

Table 4. Multivariate logistic regression model assessing factors associated with partner communication for women

Variable	Adjusted OR ᵗ	95% CI	p-value
Radio ownership	2.56	1.32-4.96	<0.01
Having high levels of discrimination/exp. stigma	0.31	0.15-0.62	<0.01
Having favorable social norms of HIV prevention	2.57	1.29-5.09	0.01
Agree that: "*Women's wishes should be taken into account when making decisions in the home*"	4.48	1.45-13.87	0.01
Agree that "*Women should be allowed to work outside the home*"	2.86	1.05-7.83	0.04
Participating in at least 1 social group	2.41	1.26-4.62	0.01

ᵗAdjusted for age, marital status, religion, ethnic group, village, and household size

For males, the final multivariate regression model included five variables: Condom use, having a young sexual partner, favorable social norms about HIV prevention, social participation, and the gender norm relating to women working outside the home. Partner communication was inversely associated with using condoms (comparing some use to "never" use) and having a young sexual partner. Having favorable norms toward HIV prevention and participating in at least one social group were all significantly positively associated with partner communication. Regarding gender norms, men who agreed that women should be allowed to work outside the home had over 12 times the odds of communicating with their sexual partner as compared to men who disagreed with this statement. Results are presented in Table 5.

Table 5. Multivariate logistic regression model assessing factors associated with partner communication for men

Variable	Adjusted OR[ϯ]	95% CI	p-value
Using condoms at least some of the time in past 6 months	0.44	0.19-1.00	0.05
Sexual partner is ≤25 years old	0.29	0.12-0.75	0.01
Agree that "*women should be allowed to work outside the home*"	12.73	3.63-44.69	<0.001
Having high levels of social norms	2.49	1.15-5.41	0.02
Participating in at least 1 social group	2.48	1.14-5.37	0.02

[ϯ]Adjusted for age, marital status, religion, ethnic group, village, and household size

Discussion

Despite clear evidence that gender inequalities shape HIV risk, gaps exist in understanding the specific pathways through which such inequalities influence HIV vulnerability[44]. This study sheds light on one potential link in the casual pathway between gender and HIV—partner communication. Results from this analysis demonstrate that partner communication about HIV is a gendered occurrence, with

predictors of communication constrained by hegemonic notions of masculinity and female passivity that characterize Tanzanian society. Below we outline the significance of these findings within the main constructs of the Theory of Gender and Power and highlight how these findings can be used to inform HIV prevention interventions.

Regarding the sexual division of labor, women with higher SES, higher educational attainment, and employment with a fixed salary all communicated more with their sexual partners about HIV in this study. These results are consistent with previous research demonstrating an inverse association of women's economic dependence and partner communication about HIV[45], as well as links between economic vulnerability and HIV-related risk more generally[20, 46]. Increasing women's economic empowerment has already been identified as a critical structural-level factor in preventing HIV [47], and interventions ranging from cash transfer projects[48] to microfinance and microenterprise programs[49, 50] have demonstrated moderate successes, but also some failures suggesting that interventions may have actually increased young women's exposure to coercion and violence[51]. However, scale-up of these projects remains challenging without wide-scale investment in economic development[52], and questions remain about whether absolute increases in economic security will translate to increases in safer sex[53]. Additionally, it is important to note that *household* ownership of a radio, not women's ownership, was significantly associated with partner communication in multivariate analysis, suggesting overall household wealth may shape communication patterns more so than women's specific economic means, although more information on the relative SES between partners is needed and

was not measured in this study. To date most interventions aimed at addressing the intersection of economic vulnerability and HIV prevention have focused on women, and research is limited on income generating interventions for families and men[54].

Regarding the division of power, results from our analysis demonstrate that men's dominance in power and sexual decision-making influenced partner communication and HIV-related risk for both sexes. Men on average were more than 7 years older than their female sexual partners and over one third were 10 or more years older. Men with young partners were less likely to communicate about HIV transmission, which is concerning. Although we found no significant difference between intergenerational partnerships and communication, which contrasts with previous research on partner communication[16] and HIV-related risk[20], it is possible this effect was diluted as age disparities were widespread across the sample, thus rendering differences in communication between a 10-year age differential and a 7-year age differential inconsequential. Regarding condom use, it is noteworthy that men were less likely to communicate with their partners if they used condoms, but the same did not hold true for women. If direct communication about HIV has not taken place in a sexual dyad, using condoms is a prudent means of protection from HIV and other sexually transmitted infections. Additionally, the action of putting on a condom is an implicit communication in and of itself, and one that is controlled by men (unless female condoms are being used). The fact that condom use was not related to communication for women speaks to their relative powerlessness in negotiating condom use. Previous research has found that women feel they cannot discuss condom use with their partners

for fear of accusations of violence, infidelity, or relationship termination[55-57]. However, women may have important, logical reasons for not talking to their sexual partner or encouraging them to test, such as the risk of intimate partner violence. This demonstrates that increasing partner communication should not be recommended as a blanket strategy for HIV prevention as communication could lead to violence for some women.

Social norms about HIV prevention, social engagement, and women's role in society clearly play a significant role in influencing partner communication. Having favorable social norms about HIV prevention, which include seeing HIV testing and discussions about HIV and condom use as normative behavior, was significantly associated with partner communication for men and women. This finding is similar to results from a quantitative survey in Malawi, which found that perceived benefits and descriptive norms about condom use were significantly associated with the intention to talk about condoms[57]. Social participation was also associated with communication for both genders. This finding is supported by recent research from Tanzania that found people with low structural social capital, i.e. participation in civic activities, were more likely to be HIV-infected than those with high participation[58], as well as research from South Africa that showed HIV-risk is related to participation in social groups, although the type of group affected risk in opposing ways[59] . Together, these findings highlight the crucial role of social interactions in providing an avenue for accessing information and learning social rules that reflect community values and beliefs,[60] and the critical role of social structures in influencing personal agency and decision-making, [61] suggesting

such social factors can be intervened upon to support HIV prevention. This idea is reflected in the idea of "AIDS Competent Communities" developed by Campbell and colleagues[62], which involves creating safe social spaces where community members can engage in "critical dialogue where people feel confident, willing and able to freely engage in debate about obstacles to health-enhancing behavior" among other key characteristics[63]. The link between social norms and social participation with partner communication identified in this study highlights the potential benefits of creating and fostering such social spaces and dialogue within communities, especially as increasing community-level communication about HIV could also influence dyadic-level communication between partners.

Gender norms were also significant predictors of partner communication. Both women and men were more likely to report communication with their sexual partner if they agreed with the statement that "women should be allowed to work outside the home." This finding supports the argument that transforming gender norms requires involvement of women *and men*[64]. Garnering support from male partners and changing gender norms surrounding women's economic empowerment for both genders may help increase communication about HIV and prevent future infections. Interestingly, only women, not men, had increased odds of partner communication if they agreed with the statement that "women's wishes should be taken into account when making decisions for the home." This finding could result from the fact that having decision-making power is more important for the less powerful (i.e., women) than for those who already have power (i.e., men). It also speaks to the "vulnerability paradigm" for women

and HIV, which has been used to portray men as "active-transmitters" of HIV and women as hapless victims [65]. Research has shown that this paradigm, while accurately portraying the very real biological and social vulnerabilities of women and HIV, is too simplistic, and that in reality the societal norms, values, and beliefs influencing HIV vulnerability between genders are often much more complex[66]. Portraying women as vulnerable undermines the agency, power, and resourcefulness that women do possess[65]. Regarding the gender norm about women's decision making, it is noteworthy that the vast majority of women *and men* agreed with this statement. The fact that in this study at least one progressive gender norm was associated with partner communication for men provides support that men should be seen as "active agents in HIV prevention"[65], and suggests that gender-specific interventions can help change norms and behaviors for both genders[67].

Limitations

This study had several limitations. All information on communication, norms, and behaviors was collected through self-report, so it is possible that reported behaviors were under- or over-reported due to social-desirability bias or unease in reporting certain behaviors, such as violence, especially as interviews took place in or near participants' homes. Efforts were made to minimize this potential bias by conducting interviews in private areas and assuring participants of confidentiality. Additionally, this study used cross-sectional data, so causality cannot be inferred. The outcome for this analysis, talking with a sexual partner about HIV transmission, represents one of many

possible aspects of communication about HIV-related risk, which could also include talking about HIV testing, using condoms, and HIV in the context of reproductive health. This outcome also explicitly only asks about communication in the form of "talking" whereas communication can take other forms, including non-verbal gestures, such as simply putting on a condom before sex without prior discussion. Additionally, someone can either initiate communication or participate in communication. The variables used in these analyses did not differentiate between who was initiating communication and who was receiving it.

Further investigation as to what constitutes "communication" about HIV and sexual behavior in this setting is warranted. The candidate predictor variables used in this analysis mainly centered on the participant, although a few dyadic characteristics, including partner age differential, were collected. Additionally, this analysis did not capture relationship dynamics, such as relationship satisfaction, power, relative wealth and education of partners, length of commitment, and other variables that could be important in partner communication.

Conclusions

Dyadic factors, such as partner communication about HIV, play a critical role in sexual transmission of HIV[2]. However, as this study demonstrates, gender norms and inequalities affect communication in significant ways. Using the Theory of Gender and Power as a lens to view the data, we mostly found support that gender inequalities in labor, power, and societal norms influence who communicates about HIV and who does

not. However, we did not see opposing symmetries in predictors of communication for men and women, suggesting a more complicated picture. Results show that norms and structural-level factors can influence the communication patterns of both men and women in positive ways, such as by having favorable norms toward HIV prevention and espousing more gender-equitable norms about the roles of women in society. This finding reflects a growing body of work that goes beyond the "vulnerability paradigm" and supports the positive ways both genders can change in through interventions at the community-level[68, 69] and through gender-specific interventions that target women and girls[70] as well as boys and men[67].

Although partner communication occurs on a dyadic level, results from this study show that drivers of communication are also inherently socially and structurally-based. Creating change will require interventions at multiple levels—from interventions to improve individual and dyadic-level communication and negotiation skills to interventions at the social-level targeting increased community dialogue about HIV, and structural-level interventions aiming to change norms and inequitable gender policies.

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CONCLUSIONS

Overall findings

This dissertation explored factors related to prior HIV testing and partner communication, specifically looking at differences in motivation and behavior between men and women. A critical focus of the manuscripts was examining how communication within dyads shapes behavior, i.e. HIV testing, and in turn seeking to understand what shapes dyadic communication, i.e., social- and structural-factors. Additionally we created risk assessment tools for men and women that can be used during HIV testing and counseling to identify clients at higher risk of HIV infection so these clients can access additional services to help reduce their HIV-related risk. One such service offered to "high risk" clients is the provision of incentivized partner referral cards, with the idea being that such cards could serve as "conversation starters" for sexual partners to discuss HIV risk and/or testing. Thus all pieces of the dissertation center around intersections of gender, communication, and sexual risk in the context of HIV testing.

Across all three manuscripts, correlates of HIV testing, partner communication, and risk were significantly different for men and women, confirming the value of taking a gendered approach. Regarding testing uptake, anticipated stigma was negatively correlated with prior testing for men but not for women. Prior conversations about HIV were positively correlated with testing for men but not for women. For women, the only correlations of prior testing included knowing someone who was living with HIV and age. Overall men tested less than women, and young people of both genders had low

levels of testing, which reflects global findings that most young people and adolescents do not know their HIV status[1]. Additionally, less than half of men and women who tested HIV-positive during the assessment reported being aware of their serostatus. These results are similar to global trends[2], yet surprising in that three decades into the HIV epidemic, people are still not getting tested for HIV, despite increased treatment availability, diversified testing modalities, and countless efforts to increase awareness and reduce stigma. Evidence from this study and others suggests that people are not testing for HIV simply because it is not a priority in their lives[3]. The implications of this finding are significant. Even targeted approaches to increase testing among high-risk and HIV-positive individuals may fail if people are aware of their risk but simply not interested in testing. Innovative testing strategies that either successfully remove barriers to testing or increase motivation are needed.

With respect to interpersonal factors related for recent HIV testing, knowing whether a sexual partner was tested for HIV was the only significant predictor of recent testing for men, signifying the importance of dyadic-level influence in testing. Previous reviews have advocated for couples-based testing as it can be a "high-leverage" intervention, which is confirmed by our findings[4]. However, this relationship did not hold true for women. This demonstrates that women, because they test more for HIV than men, have a higher burden to disclose their HIV status than men[5], and potentially a greater burden to get their partners tested if couples-based testing is promoted. Provider-initiated testing through PMTCT programs removes the initial barrier to testing by making testing a routine procedure[6], but replaces it with the burden of disclosure

and partner testing encouragement for women. Findings from Rwanda suggest that the burden of HIV prevention, such as the responsibility of supplying condoms, is placed on women despite men's control over sexual decision-making[7]. Qualitative findings from Tanzania suggest women can be coerced into couples-based testing by being denied antenatal care until they bring their partners in for testing[8]. This strategy not only violates basic human rights, but could also increase women's risk of intimate partner violence and other negative consequences. Regardless of which testing modality is used, testing should always be voluntary, free from coercion, and rights-based.

In terms of risk assessment, encouraging high-risk and HIV-infected people to test for HIV in future programs will be critical in order to reach current targets for increasing enrollment in HIV treatment[9], thus leading to reduced infectivity and eventual epidemic control. In this dissertation we developed risk assessment tools that categorized HTC HIV-uninfected clients as at high- or low-risk for HIV infection, which correctly classified approximately three-quarters of HIV infections. Additionally, the tools used simple questions and graphical presentations of data to facilitate ease of interpretation and use in clinic-based settings. However, these tools also demonstrated that in generalized epidemic settings, risk is not always straightforward. For example, over a third of women who were HIV-infected in Project Accept were older (≥27 years), married, reported little condom use (but most were married and reported only one sexual partner), and reported two lifetime sexual partners. Although these women are at heightened-risk of being HIV-infected, they might not consider themselves at-risk. The implications of this finding are two-fold. First, estimating HIV-related risk is at the

individual level might not portray an accurate level of risk. For married women not already HIV-infected, studies have demonstrated that risk is mainly related to partner and couple-based factors[4, 10]. Creating a dyadic-based risk score based on the behaviors of both partners of a sexual dyad would be more accurate[11], although logistically more difficult to obtain. Despite this limitation, identifying individuals at heighted-risk of infection remains a pressing need, and using risk assessments to provide high-risk individuals with partner referral cards, as we are currently testing in the Triage Project, could lead to a new model of HIV testing, where cards serve as a "conversation starter" to help couples communicate about HIV risk and testing.

Regarding factors related to partner communication, both men and women had higher odds of partner communication if they had more progressive gender norms, more favorable social norms toward HIV prevention, and reported some social engagement. This finding speaks to the importance of social-level factors influencing dyadic-based communication. Indeed new understandings of mass media campaigns suggests that effects of such campaigns are either mediated through or moderated by interpersonal communication[12]. Traditionally communication theories hypothesized that community opinion leaders moved information through social networks, but a large study testing this hypothesis for HIV prevention failed to demonstrate an effect[13]. More research is needed to understand how norms and community-level communication influence communication at the dyadic-level.

Factors that were associated with partner communication for one gender but not the other, such as men with young partners reporting less communication and condom use being associated with less communication for men but not women, suggest that gender norms clearly play a role in communication and support using gender-based theories, such as the Theory of Gender and Power, to interpret results. This lends support to the idea that changing community-level gender norms could have implications for dyad communication as well.

Implications for interventions

Dyads clearly matter in HIV prevention and treatment, but they are rarely the focus of interventions[4, 10], and interpersonal factors are often overlooked[11]. Findings from this dissertation indicate that dyadic-based interventions and interpersonal factors deserve more attention in HIV prevention. It is important to note that dyadic-level interventions should not be restricted to dyadic-level components only, such as building communication skills for couples, but should also involve community-level factors and gender-specific elements. Below we outline three main ways findings inform future interventions related to HIV testing and two critical components to address partner communication.

HIV Testing—Promoting gender equity, partner-involvement, gender-specific programs

HIV testing services need to be proactive and gender-sensitive. They should speak to the needs and desires of both genders, each of which may be best reached

through different strategies. Several approaches to testing could promote gender equity, including community-based testing. Community-based testing includes modalities such as home-based testing, school-based testing, workplace testing, and mobile-testing, which have been shown to have higher rates of uptake than facility-based testing but result in a lower rate of identifying people living with HIV[14]. More specifically, home-based testing is a promising strategy for women and men's equal engagement, and might have the advantage of accommodating traditional gender norms, such as by allowing the man to take responsibility for his household's health[15, 16]. Another strategy for engaging men and women is extending HTC services to include other disease screening, such as screening for non-communicable disease. Studies from Uganda have demonstrated that holding community screening events for HIV, TB, malaria, hypertension, and diabetes led to significant uptake and diagnosis of new cases across all diseases[17, 18].

In addition to strategies that promote gender equity, testing modalities that leverage partners to test, either serially or simultaneously, could be particularly useful in identifying high-risk individuals and sexual networks. Methods for this type of testing include traditional couples-based testing[4], but also incentivized partner referral (such as in the Triage Project), partner notification strategies[19, 20], and invitations for male partners in PMTCT programs to come to test[21]. Using risk assessment tools for identifying individuals who test HIV-negative but have high risk could be a welcome addition to partner notification and referral strategies, which typically only focus on people who test HIV-positive. Additionally, interventions that provide some sort of

tangible invitation, such as a letter or a referral card, have the added benefit of providing a "conversation starter" which an individual can use to engage his or her partner in communication about HIV testing and HIV risk. Testing campaigns should be flexible when it comes to involving dyads. Couple counseling should never be required, but encouraging partner involvement in the ways described above could lead to a significant increase in partner testing.

Having gender-specific components of HIV testing strategies is an important way to address gender-specific motivations for testing. For example, for males, findings from this dissertation suggest that efforts need to reduce the fear of testing and market testing toward more traditional gender norms. One potential way of achieving this is to portray men on ART as "strong" and as "protecting" their families from risk of transmission. A study from Malawi recently found that explaining the benefits of treatment as prevention by showing a graphic depicting that ART lowers the amount of HIV in the body was found to reduce stigma about treatment and increase testing[22]. Perhaps a similar intervention geared toward men would help lessen fear of testing and promote the idea of ART as providing masculine ideals, including strength and role of the protector. Additionally, having HIV testing onsite at drinking establishments may help get men to test as alcohol use and HIV testing were inversely correlated in our findings[23]. Given the correlation between previous communication about HIV and prior testing for men, finding ways to increase community dialogue about HIV could be beneficial. For women, routine testing as part of PMTCT programs is effectively increasing testing among women. However, female-specific interventions aimed at

increasing testing among non-pregnant women and young girls are warranted. Given that knowing someone who is living with HIV was significantly correlated with HIV testing for women, perhaps presenting positive narratives of women living with HIV would help increase testing among this group. Additionally, it is important that strategies counter the norm that HIV testing is an intervention just for women, which is being reported as a common belief among men across sub-Saharan Africa[24-26]. As previously discussed, relying on women to get men to test results in an undue burden. Instead, we need to find ways on increasing male testing. Strategies for increasing testing for young people of both genders are also urgently needed[1].

Interventions to increase partner communication

This dissertation found that partner communication is important for HV testing uptake, which adds to previous literature showing partner communication is also associated with protective behaviors related to HIV prevention, such as condom use[27]. To increase partner communication, we need to develop and provide communication tools. Discussing sex and sexually transmitted infections with sexual partners can be difficult and culturally taboo[28]. Research has shown that young people in Tanzania often lack communication skills, restrict communication about sex due to gender norms, and have low health literacy overall[29]. Given this context, communication about HIV seems fraught with challenges. Interventions such as Stepping Stones, which seeks to build communication skills and change gender norms, have resulted in some behavior changes, but not an actual decrease in HIV incidence[30]. We need more interventions that teach communication skills, particularly for young people. However, providing

people tools to increase communication does not necessarily equate to just building communication skills. Providing people with conversation starters, such as referral cards or some other cue to action, has the potential to increase communication about HIV by providing an indirect way of bringing up a sensitive subject. In the Triage Study, the referral cards for sexual partners come with the promise of a small commodity-based incentive if the partner comes in for testing. Therefore, the promise of an incentive could enable an HIV-related conversation between partners on a positive subject—economic gain—as opposed to focusing solely on sensitive issues such as HIV. Within the Triage Project more research is planned to investigate how the referral cards and promise of incentives influence partner communication.

Another critical factor in increasing partner communication is changing gender and social norms related to HIV prevention. In this dissertation having favorable social norms toward HIV prevention, progressive gender norms, and participation in at least one social group were significantly associated with partner communication for both men and women. As previously discussed, dyadic-level communication is clearly influenced by social and gender norms. Therefore, intervening at the community-level to change these norms could have significant consequences for other levels of the Social Ecological Model, including the interpersonal level. One intervention in Uganda, SASA!, a community mobilization intervention to reduce intimate partner violence, found significant increases in open communication and joint-decision making between partners in intervention communities, as well as increases in condom use and

reductions in multiple current partnerships[31]. Studies like SASA! demonstrate the interconnectedness of social, interpersonal, and intrapersonal levels of behavior change.

The way forward

Increasing HIV testing, improving partner communication, and creating more gender equitable communities requires both short- and long-term goals. In the short-term, we need to rapidly increase rates of HIV testing by meeting people where they are, on their own terms. If women cannot talk to their partners about HIV testing but could use a tangible cue to action to facilitate a conversation, we need to create this type of intervention. If inviting men to participate in couples-based testing and counseling requires not mentioning HIV testing anywhere on the invitation letter, this is the type of intervention to create now. However, in the long-term, we need to aim higher. We need to work toward changing social norms toward HIV prevention, promoting gender equity, and facilitating healthy relationships between partners, which will benefit the health and well-being of men and women more broadly. Interventions like SASA! show these transformations are possible, but creating sustainable change will involve incremental steps, and we need more research to understand the social context and pathways through which these interventions work. We need more data disaggregated by gender to better understand differences between men and women and design interventions accordingly. Finally, we need to understand synergies between interventions and how they work across multiple spheres of influence. Creating change within a dyad requires change to the larger context in which people live.

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Appendix 1: Risk assessment questionnaires

Female Questionnaire:

1. What is your current marital status?
    d. Widowed➔If widowed, the client has a heightened chance of being HIV-infected. However, since the client tested HIV-negative during VCT, the client is not at higher risk of becoming HIV infected at this time.
    e. Married, separated, divorced, or single➔ proceed to **Q2**
2. What is your age?
    a. ≤26 ➔*If 26 years or below, proceed to **Q3***
    b. >26 ➔If greater than 26 years, proceed to **Q7**
3. Have you had more than one sexual partner in your lifetime?
    a. ≤1 ➔If one sexual partner or less, the client is at low risk of becoming HIV-infected at this time.
    b. >1 ➔*If greater than one sexual partner, proceed to **Q4***
4. Have you had an HIV test in the past year?
    a. Yes➔ The client is at low risk of becoming HIV-infected at this time.
    b. No➔ *proceed to **Q5***
5. Have you ever drunk alcohol?
    a. Yes➔ this client is at heightened risk of becoming HIV-infected.
    b. No➔ *proceed to **Q6***
6. Have you had more than 3 sexual partners in your life?
    a. Yes➔ this client is at heightened risk of becoming HIV-infected.
    b. No➔ the client is at low risk of becoming HIV-infected at this time.
7. In the past 6 months, how often was a condom used by you or your sexual partner when having sex?
    a. Always condom use➔ If the client reports always using condoms, there is a heightened risk that the client is HIV-infected. However, since the client tested HIV-negative, the client is not at a higher risk of becoming HIV-infected at this time. Encourage the continued use of condoms.
    b. No condom use, or some condom use ➔*If none or some condom use, proceed to **Q8***.
8. Has a sexual partner hit, slapped, or otherwise physically hurt you in the past year?
    a. Yes➔ this client is at heightened risk of becoming HIV-infected.
    b. No➔ *proceed to **Q9***
9. Are you currently single, divorced, or separated?
    a. Yes➔ this client is at heightened risk of becoming HIV-infected.
    b. No➔ *proceed to **Q10***
10. Have you had more than one sexual partner in your lifetime?
    a. Yes➔ this client is at heighted risk of becoming HIV-infected.
    b. No➔ the client is at low risk of becoming HIV-infected at this time.

Male Questionnaire:

1. What is your current marital status?
    a. If single, married, or widowed, proceed to Q3
    b. If divorced, separated, or married but living separately for work, proceed to Q2
2. Have you had more than 4 sexual partners in your life?
    a. Yes➔At this time you are at heightened risk of being infected with HIV.
    b. No➔ At this time you are at low risk of being infected with HIV.
3. How old are you?
    a. If 25 years old or younger, proceed to Q4
    b. If 26 years old or older, proceed to Q5
4. Have you had more than 4 sexual partners in your life?
    a. Yes➔At this time you are at heightened risk of being infected with HIV.
    b. No➔ At this time you are at low risk of being infected with HIV.
5. In the past 6 months how often was a condom used by you or your partner when having sex?
    a. Always➔ At this time you are at low risk of being infected with HIV.
    b. Sometimes or never➔proceed to Q6
6. Have you ever drunk alcohol?
    a. Yes➔ At this time you are at heightened risk of being infected with HIV.
    b. No➔ At this time you are at low risk of being infected with HIV.

Appendix 2: Operationalization of latent variables and scale construction

Variable	Measurement	Survey questions	Alpha
Social norms	Scale created using 4 items (Likert scale response choices); scale dichotomized at the median. Low scores indicate testing and communication was not a norm; high scores indicate testing and communication is norm	1. Most people in Kisarawe have been tested for HIV. 2. Most people in Kisarawe want to get tested for HIV. 3. People in this community discuss HIV with their sexual partners 4. People in this community discuss condoms with their sexual partners	0.71
Social participation	Index created by summing responses to participation in 4 different types of social groups. Participation was categorized as no social engagement or any engagement (reporting participation in at least one type of social group)	1. Religious groups (related to mosque/church) 2. Social groups (ex: women's groups, support groups) 3. Work-related groups (ex: agricultural coops) 4. Savings or lending groups (ex: SACCHOS)	n/a
Anticipated stigma	Measured using 1 question. Response choices dichotomized by agreement (agree/strongly agreement) and disagreement (disagree/strongly disagree)	"People are hesitant to take an HIV test due to people's reaction if the test result is positive for HIV"	n/a
Perceived stigma	Scale created using 5 items (Likert scale response choices); scale dichotomized at the median (high vs. low perceived stigma).	1. People talk badly about people living with or thought to be living with HIV to others 2. People living with or thought to be living with HIV lose respect. 3. People living with or thought to be living with HIV are verbally insulted, harassed, and/or threatened. 4. People living with or thought to be living with HIV are sometimes physically assaulted. 5. People living with HIV are less able to financially support themselves and their families	0.75
Experienced stigma/ discrimination	Scale created using 3 items (Likert scale response choices);	1. I would buy fresh vegetables from a vendor if I knew this person is living with HIV 2. I think that if a female teacher is living with HIV but is not sick, she should be able to continue teaching at school. 3. Children living with HIV should be able to attend school with children who are HIV negative	0.80

Curriculum Vitae

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PERSONAL DATA

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EDUCATION

Doctor of Philosophy, **International Health** September 2015
Social and Behavioral Interventions Program
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
GPA: 4.0/4.0
Awards: Robert D. and Helen S. Wright Fellowship (2012), Sommer Scholarship (2013)

Health and Human Rights Certificate May 2012
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
GPA: 4.0/4.0

Master of Public Health May 2010
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
GPA: 3.9/4.0
Concentration: Social and Behavioral Sciences
Award: SOURCE Community Service Award- JHU Student Outreach Resource Center

Bachelor of Arts in Psychology April 2005
Pepperdine University, Malibu, CA
GPA: 3.8/4.0
Honors: *Magna cum laude,* Psi Chi Honor Society, Golden Key Honor Society

FIELD EXPERIENCE

The Medical University of South Carolina, Charleston, SC (via Kisarawe, Tanzania)
Program Manager October 2012-present

- Managing the development and implementation of a phase II community randomized trial in Kisarawe District, Tanzania to understand the effects of a combination HIV prevention intervention involving community mobilization, the creation of a community HIV prevention center, provision of incentives for high-risk individuals to bring their sexual partners in for HIV testing and provision of additional counseling, and active referral and support for all individuals who test positive for HIV. This trial is supported by NIMH (R01MH095869-01A1).
- Collaborating with Muhimbili University in Dar es Salaam and project staff to develop data collection tools, project protocol, training manuals, standard operating procedures, and IRB applications and amendments.

Johns Hopkins University, Research to Prevention Project, Mbabane, Swaziland
Interim Research Coordinator July 2011-August 2011

- Collaborated with the Swaziland Ministry of Health and PSI to help collect data for a research study examining social and structural factors related to HIV risk among sex workers and men who have sex with men in Swaziland. The study employed Respondent Driven Sampling (RDS) to recruit participants.
- Oversaw day to day project activities, including staff debriefing meetings, data accrual, and interactions with implementing partners.

United States Peace Corps, Zambia, Southern Africa
HIV/AIDS Community Mobilizer June 2006- July 2008

- Developed and implemented curricula for community HIV/AIDS prevention programs in a rural area of Zambia containing 12,000 people.
- Successfully wrote, applied for, and received grants from the President's Emergency Plan for AIDS Relief (PEPFAR) to create a Youth Resource Center and train 20 peer counselors in HIV/STI prevention, life skills, and counseling.
- Trained community health workers, facilitated workshops, and sensitized 14 communities regarding HIV/AIDS, nutrition, and participatory strategies for improving community health.
- Created and coordinated support networks and trainings for 60 people living with HIV.
- Elected by peers to the Volunteer Advisory Committee acting as a liaison between 150 Peace Corps volunteers and senior staff regarding policy issues.
- Facilitated educational workshops on income generating activities for several women's groups and helped create a girls' empowerment program at the local school.

PROFESSIONAL EXPERIENCE

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD and
The Medical University of South Carolina, Charleston, SC
Senior Research Program Coordinator July 2010-present

- Coordinating the research and implementation of two NIH-sponsored research grants (R01MH090173-01: Synthesizing HIV Behavioral Intervention Effectiveness in Developing Countries and RC1MH088950-01: Cost-effectiveness of HIV-related Mental Health Interventions) relating to systematic reviews.
- Supervising a team of 6 research assistants, including training, delegating tasks, and monitoring performance.
- Co-authoring nine systematic reviews on the effects of 1) voluntary counseling and testing, 2) provider-initiated testing and counseling, 3) condom social marketing, 4) income generation, 5) school-based sex education, 6) family planning counseling, 7) behavioral counseling, 8) free condom distribution, and 9) interventions to increase disclosure in low- and middle-income countries.
- Co-facilitating project meetings and conference calls with principal investigators from the World Health Organization, Medical University of South Carolina, and the Johns Hopkins School of Public Health.

World Health Organization, Geneva, Switzerland
Consultant Oct. 2010-June 2015 (intermittently)

- Collaborated with investigators from the World Health Organization to conduct systematic reviews to aid in the formation of international guidelines for the following:
  - Oral pre-exposure prophylaxis (PrEP) for preventing HIV infection among women, serodiscordant couples, men who have sex with men and transgender people, people who inject drugs, and all people at substantial risk of HIV infection
  - Empowerment interventions for preventing HIV/STI infection among sex workers in developing countries
  - Classification of misdiagnosis of HIV during HIV testing and counseling
- Developed protocols for systematically reviewing the evidence of effectiveness for the previous topics, performed database searches, screened abstracts, abstracted data, wrote results for dissemination, and entered results into GRADE software.

Johns Hopkins Center for Communication Programs, Baltimore, MD
Research Assistant, Research to Prevention (R2P) Project July 2012-Nov. 2012

- Wrote protocol for implementing a Time-Location-Sampling (TLS) strategy for recruiting a cohort of 1200 sex workers for a USAID-funded combination HIV prevention trial taking place in Iringa, Tanzania.
- Developed data collection instruments for the TLS protocol, including a formative evaluation questionnaire for potential study venues and several forms for enumerating potential study participants.

Clinton Global Health Access Initiative, Ney York City, NY May 2012- July 2012
Consultant

- Wrote protocol for conducting qualitative research to explore reasons why certain health facilities in 5 African countries have high cost and low patient retention or low cost and high patient retention in regards to HIV-related care and treatment.
- Helped develop a framework to assess drivers of cost and retention in HIV-related health care in resource-poor settings which was used to construct qualitative data collection tools.

Johns Hopkins University Center for Communication Programs, Baltimore, MD
Research Assistant Feb. 2010- June 2010

- Conducted meetings to acquire information regarding public private partnerships relating to public health programs which resulted in the compilation of a comprehensive list of private partner support.
- Implemented literature searches using PubMed on the role of public-private partnerships regarding health in developing countries and compiled results into written reports and organized spreadsheets.

National Cancer Institute, Bethesda, MD
Cancer Research Training Award Fellowship March 2009- June 2009

- Designed a survey and a methodology for obtaining data from public water utilities for an epidemiological study examining bladder cancer and water quality.
- Interviewed state health departments and 50 public water utilities to collect data.

The Dartmouth Institute for Health Policy and Clinical Practice, Lebanon, NH
Health Quality Research Volunteer Oct 2008- Jan 2009

- Assessed a Community Health Center's readiness to integrate a health survey system allowing for improvements in preventative health initiatives and quality of healthcare.
- Researched and wrote a collaborative report detailing the assessment findings, including identification of potential benefits and barriers to implementing the survey system.

PUBLICATIONS (NOTE: Prior to June 2012, maiden name was Virginia A. Tedrow)

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2. **Fonner VA,** Kerrigan D, Mnisi Z, Ketende S, Kennedy CE, Baral S. Social Cohesion, Social Participation, and HIV Related Risk among Female Sex Workers in Swaziland. *PLoS One*. 2014;9(1):e87527.

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4. **Fonner VA**, Denison J, Kennedy CE, O'Reilly K, Sweat M. Voluntary counseling and testing (VCT) for changing HIV-related risk behavior in developing countries. *The Cochrane Database of Systematic Reviews*. 2012;9:CD001224.

5. Kennedy CE, **Fonner VA**, Armstrong K, O'Reilly KR, and Sweat MD. Increasing HIV serostatus disclosure in low- and middle-income countries: A systematic review of intervention evaluations. *AIDS (London, England)*. Jun 2015;29 Suppl 1:S7-S23.

6. Kerrigan D, Kennedy CK, Cheng A, Sandison S, **Fonner VA**, Holtgrave D, and Brahmbhatt H. Advancing the Strategic Use of HIV Operations Research to Strengthen Local Policies and Programs: The Research to Prevention (R2P) Project. *Journal of the International AIDS Society*. 2015;18(1):20029.

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11. Kennedy CE, **Fonner VA**, O'Reilly KR, Sweat MD. A systematic review of income generation interventions, including microfinance and vocational skills training, for HIV prevention. *AIDS Care*. 2014;26(6):659-673.

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17. **Tedrow VA**, Zelaya C, Kennedy C, Morin S, Khumalo-Sakutukwa G, Sweat M, et al. No "Magic Bullet": Exploring Community Mobilization Strategies Used in a Multi-site Community Based Randomized Controlled Trial: Project Accept (HPTN 043). *AIDS and Behavior*. Jul 2012; 16(5):1217-1226.

POSTERS AND PRESENTATIONS

1. **Fonner VA**, Mbwambo J, Kennedy CE, Sweat MD. An exploratory analysis using categorization and regression tree (CART) methods to identify men at high risk for HIV infection in Kisarawe, Tanzania. International AIDS Conference 2014, Melbourne, Australia. Poster presentation; Thursday, July 24, 2014.

2. **Fonner VA**, Kerrigan D, Mnisi Z, Ketende S, Kennedy CK, Baral S. "Social cohesion, social participation and HIV related risk among female sex workers in Swaziland." 7th IAS Conference on HIV Pathogenesis, Treatment, and Prevention, Kuala Lumpur, Malaysia. Oral poster presentation; Wednesday, July 3, 2013.

3. Ploth D, Mbwambo J, **Fonner VA**, Horowitz B, Zager P, Frederick F, West C, Sweat MD. "Prevalence of chronic kidney disease, diabetes and hypertension in rural Tanzania." ISN World Congress of Nephrology 2015. Poster presentation; Monday, March 16, 2015.

4. Johnson C, Sands A, **Fonner VA**, Sharon Tsui, Wong V, Obermeyer C, Baggaley R. Are We Delivering the Wrong Results? Examining Misclassification of HIV Status and False Positive Test Results. African Society for Laboratory Medicine Conference, Cape Town, South Africa. Oral presentation; December 2014.

5. Kennedy CE, Armstrong K, **Fonner VA**, Sweat MD, O'Reilly, KR. "Is use of antiretroviral treatment associated with decreased condom use? A meta-analysis of studies from low- and middle-income countries?" International AIDS Conference 2014, Melbourne, Australia. Oral presentation; Wednesday, July 23, 2014.

6. **Tedrow VA**, Kennedy CE, O'Reilly KR, Sweat MD. "Systematic assessment of condom use measurement in behavioral HIV prevention research: need for standardization of measures." International AIDS Conference 2012, Washington, DC. Poster presentation; Monday, July 23, 2012.

7. **Tedrow VA**, Denison JA, Kennedy CE, O'Reilly KR, Sweat MD. "Voluntary counseling and testing (VCT) for changing HIV-related risk behavior in developing countries." International AIDS Conference 2012, Washington, DC. Poster presentation; Tuesday, July 24, 2012.

8. **Tedrow VA**, Mnisi Z, Kerrigan D, Dalmini M, Dludlu V, Phakathi M, Kennedy C, Baral S. "Measuring social capital among female sex workers in Swaziland: Implications for HIV prevention." International AIDS Conference 2012, Washington, DC. Poster presentation; Tuesday, July 24, 2012.

9. O'Reilly KR, **Tedrow VA**, Kennedy CE, Sweat MD. "Preventing HIV infection in biomedical prevention trials: are even the "failures" are preventing HIV?" International AIDS Conference 2012, Washington, DC. Poster presentation; Tuesday, July 24, 2012.

10. Kerrigan DL, **Tedrow VA**, Stromdahl S, Kennedy CE. "Community empowerment among sex workers is an effective HIV prevention intervention: Findings from a systematic review of the peer-reviewed evidence." International AIDS Conference 2012, Washington, DC. Poster presentation; Thursday, July 26, 2012.

11. **Tedrow, VA.** "Peer Education and HIV Prevention: A Systematic Review of the Evidence." Oral Presentation. Peer-to-Peer Outreach Program Workshop, Cornell University, Ithaca, NY. April 19, 2011.

12. O'Reilly KO, **Tedrow VA**, Kennedy CE, Sweat MD. "The Challenge of Making HIV Prevention Policy and Guiding HIV Prevention Programs with Imperfect Data." Oral Presentation. The World Health Organization, Geneva, Switzerland. October 27, 2010.

13. **Tedrow VA**. "Qualitative Research Theory and Methods." Oral Presentation. Research to Prevention Small Grants Workshop, USAID, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD. September 22, 2010.

PUBLICATIONS AND BOOK CHAPTERS UNDER REVIEW

1. Denison J, **Fonner VA**, Kennedy C, Sweat M. HIV counseling and testing, Prevention of HIV. *Encyclopedia of AIDS*. Eds. Thomas Hope, Douglas D. Richman and Mario Stevenson. Under review with Springer.

2. Grover E, Grosso A, Ketende S, Kennedy C, **Fonner VA**, Adams D, Sithole B, Mnisi Z, Maziya SL, Baral S. Social cohesion, social participation and HIV testing among men who have sex with men in Swaziland. Submitted to *AIDS Care* in July 2015.

3. West C, Ploth D, **Fonner VA**, Mbwambo J, Fredrick F, Sweat M. Developing a screening algorithm for type II diabetes in the resource-limited setting of rural Tanzania. Submitted to *The American Journal of the Medical Sciences* in July 2015.

GRANTS

Fonner VA. Triaging and Incentivizing Voluntary Counseling and Testing (VCT) for HIV Prevention in Rural Tanzania: Assessing Participants' Experience. Center for Qualitative Studies in Health and Medicine Award Recipient 2013-2014.

Fonner VA. Measuring Social Capital among Female Sex Workers in Swaziland: Implications for HIV Prevention. September 2012. Small Grant Award Recipient under U.S. Agency for International Development (USAID) Contract No: GHH-I-00-07-00032-00 for the HIV Prevention Program Research (R2P) Task Order.

Tedrow VA. Mulilima Youth Friendly Corner Peer Educator Workshop. April 2008. Funded by: The President's Emergency Plan for AIDS Relief (PEPFAR) and the U.S. Peace Corps/Zambia Volunteer Activities Support and Training (VAST) grant.

Tedrow VA. Mulilima Youth Friendly Corner Restoration: Imiti Iikula e Mpanga. December 2007-March 2008. Funded by: The President's Emergency Plan for AIDS Relief (PEPFAR) and the U.S. Peace Corps/Zambia Volunteer Activities Support and Training (VAST) grant.

TEACHING

Teaching Assistant, Health Behavior Change at the Individual, Household, and Community Levels. Primary instructors: Drs. Peter Winch and Julie Denison, Johns Hopkins Bloomberg School of Public Health, 2nd term 2011 and 2012

Teaching Assistant, Statistics for Psychosocial Research: Measurement. Primary Instructor: Dr. Jeannie-Marie Leoutsakos, Johns Hopkins Bloomberg School of Public Health, 1st term 2012

Teaching Assistant, Qualitative Research Theory and Methods. Primary instructors: Drs. Joel Gittelsohn and Caitlin Kennedy, Johns Hopkins Bloomberg School of Public Health, 3rd term 2012

Teaching Assistant, Qualitative Data Analysis. Primary instructors: Drs. Peter Winch and Steve Harvey, Johns Hopkins Bloomberg School of Public Health, 4th term 2012

Tutor, Statistical Methods in Public Health (Biostatistics). Johns Hopkins Bloomberg School of Public Health, September 2010-May 2012

PEER REVIEW

Served as a manuscript reviewer for the following journals:

International Journal of HIV and STIs, March 2015;
SpringerPlus, October 2014;
Health Education Journal, May 2014;
Reproductive Health, April 2014;
BioMed Central, November 2012 and January 2014;
British Medical Journal, May 2012;
Public Health, February 2012 and August 2012;
Journal of Public Health in Africa, September 2011;
Cochrane Collaboration, July 2011

SERVICE

Diversity and Academics Advancement Summer Institute (DAASI), Volunteer Supervisor/Mentor, June-August 2011
People's Community Health Center, HIV/AIDS Counseling and Testing Student Volunteer Leader**,** October 2009-May 2010

PROFESSIONAL DEVELOPMENT

Language Skills: IciBemba (highly proficient), KiSwahili (working knowledge)

Computer Skills: STATA, SPSS, and MPLUS (Biostatistics); Microsoft Office Suite; ATLAS.ti (Qualitative Data Analysis software); CMA (Comprehensive Meta-Analysis software) and GRADE; EpiData (data entry software); UCINET (social network analysis software); and ANTHROPAC (software for analyzing anthropological data)

Additional Training:

- HIV Counseling Skills Level 1, Maryland Department of Health and Mental Hygiene, 2009
- Information Security Awareness Training, National Institutes of Health, 2009
- Research Ethics Training, National Institutes of Health, 2009
- HIV/AIDS, Cross-Cultural, and Bemba Language Training, Peace Corps/Zambia, 2006

Professional Membership:

Global Health Council Member, 2010-present
International AIDS Society Member, 2012-present