



Published in final edited form as:

J Choice Model. 2021 September ; 40: . doi:10.1016/j.jocm.2021.100305.

What factors influence HIV testing? Modeling preference heterogeneity using latent classes and class-independent random effects

Jan Ostermann^{a,b,c,d,*}, Brian P. Flaherty^{d,e}, Derek S. Brown^{d,f}, Bernard Njau^g, Amy M. Hobbie^{c,d}, Tara B. Mtuy^{g,h}, Max Masnickⁱ, Axel C. Mühlbacher^{d,j,k}, Nathan M. Thielman^{c,d}

^a Department of Health Services Policy & Management, University of South Carolina, 915 Greene Street, Columbia, SC, USA

^b South Carolina Smart State Center for Healthcare Quality, University of South Carolina, Columbia, SC, USA

^c Duke Global Health Institute, Duke University, Durham, NC, USA

^d Center for Health Policy & Inequalities Research, Duke University, Durham, NC, USA

^e Department of Psychology, University of Washington, Seattle, WA, USA

^f Brown School, Washington University in St. Louis, St. Louis, MO, USA

^g Kilimanjaro Christian Medical Centre, Moshi, Tanzania

^h Department of Global Health and Development, London School of Hygiene and Tropical Medicine, London, UK

ⁱ Selway Labs, LLC, Englewood, CO, USA

^j Institut Gesundheitsökonomie und Medizinmanagement, Hochschule Neubrandenburg, Neubrandenburg, Germany

^k Department of Population Health Sciences, Duke University, Durham, NC, USA

This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

* Corresponding author. Department of Health Services Policy & Management, University of South Carolina, 915 Greene Street Columbia, SC, 29205, USA. jano@mailbox.sc.edu (J. Ostermann).

CRediT authorship contribution statement

Jan Ostermann: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Visualization, Supervision, Funding acquisition. **Brian P. Flaherty:** Methodology, Software, Validation, Formal analysis, Writing – original draft, Funding acquisition. **Derek S. Brown:** Conceptualization, Methodology, Writing – original draft, Funding acquisition. **Bernard Njau:** Conceptualization, Supervision, Project administration, Funding acquisition. **Amy M. Hobbie:** Project administration, Funding acquisition. **Tara B. Mtuy:** Validation, Project administration, Supervision. **Max Masnick:** Software, Resources, Data curation. **Axel C. Mühlbacher:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **Nathan M. Thielman:** Conceptualization, Writing – original draft, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no conflict of interests.

Ethics approvals

The protocol was registered in [ClinicalTrials.gov](https://clinicaltrials.gov) (Protocol [NCT02714140](https://clinicaltrials.gov/ct2/show/study/NCT02714140)) on March 21, 2016. The protocol was approved by the Institutional Review Boards at Duke University (Duke University Health System IRB, Protocol Pro00075996) and the University of South Carolina (Health Sciences South Carolina IRB, facilitated review, Pro00060760) in the United States; as well as the Ethics Review Committee at Kilimanjaro Christian Medical University College (Protocols #273 and #901) and the National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/1 363 and NIMR/HQ/R.8a/Vol. IX/2 603) in Tanzania.

Abstract

Efforts to eliminate the HIV epidemic will require increased HIV testing rates among high-risk populations. To inform the design of HIV testing interventions, a discrete choice experiment (DCE) with six policy-relevant attributes of HIV testing options elicited the testing preferences of 300 female barworkers and 440 male Kilimanjaro mountain porters in northern Tanzania. Surveys were administered between September 2017 and July 2018. Participants were asked to complete 12 choice tasks, each involving first- and second-best choices from 3 testing options. DCE responses were analyzed using a random effects latent class logit (RELCL) model, in which the latent classes summarize common participant preference profiles, and the random effects capture additional individual-level preference heterogeneity with respect to three attribute domains: (a) privacy and confidentiality (testing venue, pre-test counseling, partner notification); (b) invasiveness and perceived accuracy (method for obtaining the sample for the HIV test); and (c) accessibility and value (testing availability, additional services provided). The Bayesian Information Criterion indicated the best model fit for a model with 8 preference classes, with class sizes ranging from 6% to 19% of participants. Substantial preference heterogeneity was observed, both between and within latent classes, with 12 of 16 attribute levels having positive and negative coefficients across classes, and all three random effects contributing significantly to participants' choices. The findings may help identify combinations of testing options that match the distribution of HIV testing preferences among high-risk populations; the methods may be used to systematically design heterogeneity-focused interventions using stated preference methods.

Keywords

Discrete choice experiment; Preference heterogeneity; Random effects latent class logit (RELCL); HIV counseling and testing; Tanzania

1. Introduction

Ambitious targets have been set by the Joint United Nations Programme on HIV/AIDS (UNAIDS), the President's Emergency Plan for AIDS Relief (PEPFAR), and by Ministries of Health across the globe to eliminate the HIV epidemic. For the year 2030, these targets include what is known as 95–95–95 - diagnosing 95% of all persons living with HIV (PLWH), initiating treatment for 95% of those diagnosed, and achieving viral suppression for 95% of those treated (UNAIDS, 2014). Progress towards diagnosing 95% of PLWH by 2030 is contingent on accelerating the uptake of HIV testing, both among higher-risk populations and across the population at large. The number of undiagnosed HIV infections is considered a major hindrance to achieving the UNAIDS targets and ending the epidemic (The Lancet, 2017).

Discrete choice experiments (DCEs) are commonly used to elicit information about individuals' preferences for varying characteristics of multi-attribute products. DCE results can be used to develop targeted, preference-informed interventions; optimal interventions may vary across and within population subgroups. DCEs have been used in various contexts related to HIV, including testing (Indravudh et al., 2017; Johnson et al., 2010; Ostermann et al., 2014, 2015; Phillips et al., 2002; Strauss et al., 2018a, 2018b), prevention (Cameron et

al., 2013; Newman et al., 2016; Quaipe et al., 2018a; Terris-Prestholt et al., 2013), service delivery (d'Elbee et al., 2018; Kruk et al., 2016; Zanolini et al., 2018), and treatment (Beusterien et al., 2007; Bregigeon-Ronot et al., 2017; Hauber et al., 2009; Ostermann et al., 2020a; Mühlbacher et al., 2013). We previously characterized the HIV testing preferences in a community sample in Tanzania and identified substantial preference heterogeneity (Ostermann et al., 2014). To our knowledge, DCEs have not been used to systematically characterize the distribution of HIV testing preferences among populations at high risk of HIV infection.

To inform the design of HIV testing interventions for high-risk populations, this study used a DCE to characterize patterns of testing preferences among female barworkers and male Kilimanjaro mountain porters, two high-risk populations in northern Tanzania. The DCE focused on policy-relevant characteristics of HIV testing programs that may be adapted to match the preferences of these populations. To identify patterns of preferences, we modeled DCE responses using a random effects latent class logit (RELCL) model. RELCL models allow the simultaneous estimation of common preference profiles via latent classes, as well as class-independent individual variation via random effects (Zhou and Bridges, 2019; Greene and Hensher, 2013; Hess et al., 2014). The findings from this study may help identify combinations of testing options that match the distribution of HIV testing preferences among the two high risk populations included in this study. More generally, the analytic approach described here may inform the systematic design of interventions in the context of preference heterogeneity.

2. Methods

2.1. Ethical approval

The study protocol was approved by the Institutional Review Boards at Duke University and the University of South Carolina in the United States, as well as the Ethics Review Committee at Kilimanjaro Christian Medical University College and the National Institute for Medical Research in Tanzania. The protocol was registered in [ClinicalTrials.gov](https://clinicaltrials.gov) (Protocol [NCT02714140](https://clinicaltrials.gov/ct2/show/study/NCT02714140)) on March 21, 2016 (Ostermann et al., 2020). Informed consent was obtained from all study participants.

2.2. Study setting

The study was conducted in Moshi, Tanzania. Moshi is the commercial center and administrative capital of the Kilimanjaro Region in Northern Tanzania and has an estimated population of about 200,000 (United Republic of Tanzania, 2012). Voluntary HIV counseling and testing (VCT) is available at 25 health facilities, including 2 free-standing VCT centers.

2.3. Study sample

Study participants were enrolled between September 2017 and July 2018. Participants comprised 300 women employed in bars, restaurants and guesthouses serving alcohol to patrons (henceforth referred to as “bars” and “female barworkers”, respectively) and 440 male mountain porters supporting climbers of nearby Mount Kilimanjaro (“male porters”).

We previously showed that female barworkers and male porters engage in higher rates of HIV risk behaviors than randomly selected male and female community members in the same setting (Ostermann et al., 2015). A census of bars and barworkers, conducted by the study team between February and June of 2016, identified 612 bars within Moshi, with 2059 age-eligible female barworkers. There are an estimated 10, 000 porters in the Kilimanjaro Region (Mitchell et al., 2009; Peaty, 2012).

Eligible study participants were residents of Moshi, able to read, and ages 18 to 49. Female barworkers were recruited from randomly selected bars; male porters were sequentially approached as they exited Mount Kilimanjaro National Park. Eligible individuals were invited to the study's research office for consent and enrollment; study compensation ranged from Tanzania Shilling (TSH) 5000 (~\$2.15) to TSH 10,000 (~\$4.30), including transport reimbursement.

2.4. Discrete choice experiment

HIV testing preferences were assessed using a DCE. The objective of the DCE was to present survey respondents with hypothetical HIV testing options that could feasibly be implemented in the study area. As such, the DCE was built on the characteristics of testing options that were available in the study area at the time of the survey, as well as characteristics that could feasibly be implemented. The design, administration, and analysis of the DCE followed the guidelines for DCE applications in healthcare (Bridges et al., 2011) and in low-income settings (Mangham et al., 2009). As with a previous DCE on HIV testing preferences in the same area, the selection of attributes was guided by focus group discussions with members of the target populations (Ostermann et al., 2014, 2015; Njau et al., 2014). The attributes and levels employed in our study were the following:

Attribute 1 – Testing venue.—In the study area, HIV testing is available at health facilities and at free-standing VCT centers. Several of these facilities also conduct outreach activities, including home-based testing, which involves a counselor coming to a client's home for VCT. Testing venue was thus implemented as a three-level attribute: testing at a *health facility*, testing at a free-standing *VCT center*, and testing at *home*.

Attribute 2 – Testing availability.—The majority of testing venues in Moshi offer HIV testing only on weekdays. However, selected facilities started making testing available on weekends. In the DCE, testing availability was implemented as a two-level, ordered, attribute describing testing availability on either *weekdays only* or *every day of the week*.

Attribute 3 – Pre-test counseling.—National testing guidelines (National AIDS Control Programme, 2019) require that, before testing for HIV, a counselor provides the client with information about HIV, risk of infection, and the HIV test. This service is referred to as *pre-test counseling*. Pre-test counseling can be done one-on-one, in a group, or with a partner in the context of couples counseling and testing. Accordingly, this attribute was implemented as a three-level attribute.

Attribute 4 – Type of sample.—Three different methods may be used to collect the sample for the HIV test. Samples can be collected using blood from the arm (*venipuncture*)

or the finger (*finger prick*), or saliva can be taken from the mouth using an *oral swab*. Accordingly, the attribute was implemented as a three-level attribute. It was emphasized that all three options give the same result; however, oral testing was not yet approved for general use in Tanzania at the time of the survey.

Attribute 5 – Additional services.—To decrease stigma and increase value, there have been efforts to integrate HIV testing with other health services (National AIDS Control Programme, 2017). This attribute was implemented as a three-level attribute describing the provision of additional services in conjunction with the HIV test, namely a complimentary *screen for other sexually transmitted infections (STIs)*, a complimentary general *health check* (e.g., blood pressure, diabetes), versus *no additional services*.

Attribute 6 - Partner notification.—For persons testing positive for HIV, the notification and testing of sexual partners is critical for identifying or preventing additional HIV infections (Brown et al., 2011; Cherutich et al., 2017; Chiou et al., 2015; Garcia de Olalla et al., 2015; Henley et al., 2013; Kahabuka et al., 2017; Landis et al., 1992; Myers et al., 2016; Rosenberg et al., 2015; Udeagu et al., 2012, 2014). Partner notification was implemented as a three-level attribute. *Self-disclosure* involves clients testing positive being encouraged to advise their partners to test for HIV. Confidential *provider notification* involves clients being asked to give the name and contact information for their partners, and a counselor later contacting these partners to test for HIV without revealing the client's name. *Automatic disclosure* involves the joint receipt of HIV test results by clients and their partners in the context of couples counseling.

2.4.1. Experimental design—We measured preferences over the full range of feasible combinations of attribute levels by presenting respondents with a range of HIV testing options, based on an experimental design, and observing their stated preferences. The experimental design of a DCE is the combination of choice tasks that allows for the independent estimation of the influence of each testing characteristic on preferences. Ngene software (ChoiceMetrics, 2017) version 1.12b was used to select an experimental design that minimized the D-error for a mixed logit model (Johnson et al., 2007). Two constraints were imposed in the selection of choice tasks for the experimental design:

1. To exclude non-feasible combinations of attribute levels for the pre-test counseling and partner notification attributes (e.g., *couples counseling* with *self-disclosure*), these two attributes were combined into a 5-level compound attribute. Four levels of the compound attribute described combinations of either *one-on-one* or *group counseling* with either *self-disclosure* or confidential *provider notification*; the fifth level described *couples counseling with automatic partner notification*.
2. Statistical priors were obtained from a pilot study with 236 female barworkers and male porters. Data were analyzed using a mixed logit model; the estimated means and standard deviations were used as priors in the search for a D-efficient design optimized for a mixed logit model.

The final design consisted of 120 tasks. Participants were randomized across 10 blocks with 12 tasks each. The order of choice tasks in a block was randomized across participants. Each choice task included three unlabeled testing alternatives; the order of alternatives was randomized within each choice task.

2.4.2. DCE administration—In-person DCE surveys were fielded by trained research staff, in Kiswahili (a language commonly used in the study area), on iPad devices, using *Comet* survey software (Selway Labs, 2017). Participants initially ranked the levels of each attribute. These data were used to populate a respondent-specific comprehension task with clearly dominant (preferred levels for all attributes) and dominated (worse levels for all attributes) alternatives, followed by 12 DCE choice tasks. In each choice task, participants were first asked to select their most preferred option from three testing options presented; in a follow-up task they were asked to select their most preferred from the two remaining options. A sample choice task is shown in Fig. 1.

2.5. Supplemental survey

A supplemental survey assessed sociodemographic characteristics and the HIV testing history of study participants.

2.6. Econometric model

Respondents' rankings of the HIV testing options presented in the DCE choice tasks were modeled with a latent class conditional logit model with three individual-level, class independent, random effects. Our model did not include alternative-specific constants because choices were unlabeled and presented in random order. Let i index respondents and t index choice tasks ($1 \leq t \leq T = 12$). Further, let $y_{it} = m$ denote respondent i 's choice of option m in task t , and let $M = 3$ denote the number of alternatives in each ranking task. The probability of response m based on the basic latent class conditional logit model, without random effects, is

$$P(y_{it} = m \mid x, z_{itm}) = \frac{\exp(\eta_m \mid x, z_{itm})}{\sum_{j=1}^M \exp(\eta_j \mid x, z_{itj})}$$

where x denotes latent class membership, z_{itm} denotes the vector of attribute levels associated with alternative m for respondent i in task t ; and $\eta_m \mid x, z_{itm}$ denotes the utility associated with alternative m conditional on membership in latent class x and attribute levels z_{itm} . The linear model for the utility of alternative m characterized by attributes z_{itm} for a member of latent class x is

$$\eta_m \mid x, z_{itm} = \sum_{p=1}^P \beta_{xp} z_{itmp}$$

where p indexes attribute levels of alternative m ($p = 1, \dots, P$); β_{xp} is the regression coefficient for attribute level p for latent class x ; and z_{itmp} is the effects coding for attribute level p in alternative m for individual i in task t .

Let F_i denote individual i 's vector of d ($d = 1, \dots, D$) scores on D independent and standard normal random effects distributions. Adding F_i to the model, the probability of respondent i making choice m is

$$P(y_{it} = m \mid x, z_{itm}, F_i) = \frac{\exp(\eta_m \mid x, z_{itm}, F_i)}{\sum_{j=1}^M \exp(\eta_j \mid x, z_{itj}, F_i)},$$

and the utility function is

$$\eta_m \mid x, z_{itm}, F_i = \sum_{p=1}^P \beta_{xp} z_{itmp} + \sum_{d=1}^D \sum_{p=1}^P \lambda_{dmp} F_{id} z_{itmp}, \quad (1)$$

where F_{id} is the random effect d for individual i , and λ_{dmp} is a coefficient (i.e., loading) relating random effect F_{id} and attribute level z_{itmp} to the utility of alternative m .

The specific model estimated here includes $D = 3$ subject level random effects that capture individual-level preference heterogeneity with respect to the following attribute domains: (a) privacy and confidentiality (F_{1j} , covering the *testing venue*, *pre-test counseling*, and *partner notification* attributes), (b) invasiveness and perceived accuracy (F_{2j} , covering the *type of sample* attribute), and (c) accessibility and value (F_{3j} , covering the testing availability and additional services attributes). These domains correspond to the three pillars of a conceptual model of preference-relevant HIV testing characteristics that we previously developed using qualitative work in the study area (Njau et al., 2014). The influence of the random effects (i.e., F_{1j} , F_{2j} , F_{3j}) on the probability of choice m is determined by the corresponding λ weights. The product term (i.e., the third term in Equation (1)) modifies the latent class-specific preference term (i.e., the second term in Equation (1)) for the individual. Thus, this model accounts for preference heterogeneity in two ways: latent classes, which capture heterogeneity in preference profiles that are shared among groups of individuals (i.e., combinations of preferences that are likely to co-occur), and additional individual-level heterogeneity in the form of domain specific random effects that capture respondents' unique attribute preferences, independent of class. Class membership is modeled as a function of only one covariate, participant type (barworkers vs. porters).

2.7. Statistical analysis

Differences in sociodemographic characteristics and HIV testing experiences between the two study cohorts were analyzed using Student's t -tests and chi-squared statistics. The DCE data, composed of rankings of the three testing options presented to participants in each choice task, were analyzed as sequential choices: following an initial choice of the most preferred of the three options presented, a second choice involved the selection of the more preferred of the two remaining options. Random effects latent class logit (RELCL) models with 1–10 preference classes and 0 to 3 continuous, normally distributed random effects were estimated in Latent Gold Choice version 5.0 (Statistical Innovations Inc. 2018). Models were estimated using expectation-maximization (EM) and Newton–Raphson (NR) algorithms, with 250 EM and 50 NR iterations, and 16 different sets of random starting values. The Bayesian Information Criterion (BIC) was used to compare model fit. The best-

fitting model was re-estimated with 150 different sets of random starting values to check that a global optimum was obtained. For the final model, correlates of class membership were evaluated using the bias-adjusted three-step approach described by Bakk et al. (2014). Additionally, separate models with the same specification were estimated for each risk group, and class membership predictions, based on modal estimated class membership probabilities, were compared between the aggregate and cohort-specific models.

3. Results

Table 1 details key demographic characteristics and the HIV testing history of study participants. Approximately half of the participants had at least some secondary school education, and most participants had tested for HIV at least once. Female barworkers were less likely to be married, had higher education, and were more likely to have tested for HIV than male Kilimanjaro mountain porters. Compared to a national sample of adults ages 18–49 residing in mainland urban Tanzania who participated in the 2016–17 Tanzania HIV IMPACT Survey (THIS) (Tanzania Commission for AIDS, 2018), female barworkers were less likely to be married, had more education, and both groups were somewhat more likely to have ever tested for HIV.

Fig. 2 shows the performance of latent class logit (LCL) models with and without random effects specifications, as measured by the BIC. The RELCL models consistently outperformed LCL models without random effects, with model performance improving with additional random effects. Comparisons of the BIC across models indicated that, among models with 3 random effects, model fit continuously improved up to 8 classes, with only marginal improvements gained from additional classes.

Note: The orange marker indicates the model presented below, selected based on the model's relative performance on the Bayesian Information Criterion (BIC).

Table 2 shows the results of the RELCL model with 8 preference classes and 3 random effects. As with a standard latent class model, the 8 preference classes represent statistical groupings of individuals with similar sets of preferences. Unlike a standard latent class model, with a RELCL model, the three random effects capture additional class-independent individual preference heterogeneity with respect to the five attributes grouped broadly into three domains: privacy and confidentiality (testing venue; pre-test counseling; partner notification); invasiveness and perceived accuracy (type of sample); and accessibility and value (testing availability; additional services).

The data included 17760 choices of 740 participants, totaling 8880 rankings (12 best and second-best choices per participant yield 12 rankings * 740 participants = 8880 rankings). The latent preference classes range in size from 6% to 19% of participants; distributions are similar between female barworkers and male porters.

Class-specific preferences for each attribute level included in the DCE are described by the estimated (effects coded) coefficients. Results indicate substantial heterogeneity; the variation in parameters within and across classes, combined with a comparatively large number of classes, preclude the labeling of classes based on patterns of coefficients. All

attribute levels except testing availability (which was constrained to be ordered), oral testing, and HIV testing only (without additional services) have positive and negative coefficients across classes, indicating that they are preferred by some groups of participants (classes) and disliked by others. The largest coefficient ranges across preference classes were observed for a health check alongside the HIV test, couples counseling with automatic disclosure of a positive HIV test result, the different testing venues, and preferences for venipuncture or finger prick.

The final column in Table 2 shows the effects of the random effects on utility. The estimated parameters (“loadings”) describe the extent to which the random effects amplify (same sign for the class-specific utility weight and the loading) or offset (different signs for the class-specific utility weight and the loading) the class-specific effect of each attribute level on utility. The effects differ greatly across attribute levels. The largest loadings were observed for (a) couples counseling and testing with automatic disclosure of a positive HIV test result, (b) oral swabs, and (c) venipuncture. The estimates indicate that for 3 out of 6 classes in which couples counseling was positively associated with utility, a difference of one standard deviation in random effect 1 more than offsets these utility gains. Similarly, a difference of one standard deviation in random effect 2 more than offsets the (average) aversion to oral swabs for all 8 classes and more than doubles the positive effect of venipuncture on utility among 4 out of 6 preference classes.

Given that the random effects have standard normal distributions, the absolute values of the loadings also characterize the variability of (class-specific) preference estimates across individuals. This individual-level heterogeneity, alongside the heterogeneity in preference profiles described by the latent classes, is visualized in Fig. 3. The distributions describe individual level relative preferences for (positive values) or aversion against (negative values) the respective characteristics evaluated in the DCE, conditional on predicted class membership (which is represented by different colors). The largest absolute loading in Table 2 (the λ value for couples counseling and testing with automatic disclosure) corresponds to the widest distributions of individual level preference estimates around class-specific means.

Table 3 documents systematic variation in estimated class membership probabilities with demographic characteristics and HIV testing history. Older, less educated, never testers were more likely to be members of Class 1; frequent testers were most likely to be members of classes 7 and 8. Whilst gender, and thus risk group, was associated with class membership (e.g., male porters were less likely to be members of classes 1, 3, and 4), the corresponding parameter estimates were smaller than those of variables describing testing history. Age, education, marital status, and testing history were significantly associated with the random effects for the confidentiality and privacy domain (λ_1), while education and a prior HIV test were associated with the random effect for the invasiveness and perceived accuracy domain (λ_2). Strong concordance was observed between study participants’ groupings into preference classes based on gender-specific vs. aggregate RELCL models (Appendix 1).

4. Discussion

In this study of the HIV testing preferences of 300 female barworkers and 440 male Kilimanjaro mountain porters, two high-risk populations in Northern Tanzania, we identified substantial preference heterogeneity across individuals. Our findings provide strong support for the provision of an array of diverse HIV testing options in the study area that target the heterogeneous testing preferences of high-risk populations.

To our knowledge this study is the largest DCE of preferences for HIV counseling and testing focused on high-risk populations and on policy-relevant testing attributes. In addition, this study is the first to specifically focus on preference heterogeneity. While prior studies, including our own (Ostermann et al., 2014, 2015), have documented preference heterogeneity, the analysis of sources of heterogeneity was limited to systematic variation in mean preference parameters between population subgroups identified on the basis of covariates. This study uses a RELCL model to jointly characterize heterogeneity in preference profiles that are shared among groups of respondents (i.e., combinations of preferences that are likely to co-occur among the two high-risk populations) and additional individual-level heterogeneity that captures respondents' unique attribute preferences, independent of class. Specifically, the latent classes capture some of the correlations among all the estimated part-worth utilities. Additionally, the three random effects, each linked to an attribute domain, and the corresponding loadings, further describe individual-level heterogeneity in the magnitude of the part-worth utilities and correlations among the part-worth utilities across attribute levels within attribute domains. Fig. 3 illustrates substantial variation in the distributions of the estimated preferences across attribute levels, classes, and individuals, thereby highlighting the distributional flexibility of the RELCL model employed in this study.

We acknowledge several limitations of the study. First, study participants were recruited from two high-risk populations in Northern Tanzania, and HIV testing options were described with only six characteristics. The number of attributes and levels presented could not cover all testing characteristics that might be important to a given participant. To ensure policy relevance, our selection of attribute levels was guided by actual and feasible characteristics across the 25 HIV counseling and testing providers in the study area. Other characteristics of HIV testing options may influence testing preferences and uptake in other settings and populations.

Second, while our study identified substantial preference heterogeneity, it was unable to discern the sources or consequences of this variation. Class membership probabilities and the distribution of random effects varied systematically with age, education, marital status, and HIV testing history (Table 3), however, the estimated distributions of the two distinct sub-populations across preference classes were nearly identical, there were no systematic differences in the distributions of random effects between barworkers and porters, and gender-specific models resulted in similar groupings of individuals as the aggregate model. While additional studies are needed to characterize the extent to which specific individual-level characteristics (e.g., knowledge and information, prior experiences with HIV testing, perceptions of HIV risk, anticipated consequences of a positive HIV test), correlate

with preferences, our results suggest that a substantial share of preference heterogeneity may not be explainable by general demographic and risk characteristics. From a policy perspective, it may thus be more important to evaluate the extent to which heterogeneous population preferences align with the characteristics of existing testing options, and to explore associations with testing uptake among high-risk populations.

Third, we acknowledge several methodological limitations. These include the lack of experimental design software that would have allowed us to identify an experimental design optimized for a latent class model; the omission of interactions; and general limitations of DCEs, such as the potential for hypothetical bias (Quaife et al., 2018b).

5. Conclusion

This study describes substantial heterogeneity in preferences for HIV testing among two high-risk populations in Tanzania, including distinct preference profiles that are shared among groups of individuals, and additional, random variation across individuals. From a practical perspective, the study results provide strong support for the provision of an array of HIV testing options to target preference heterogeneity and maximize uptake of HIV testing among high-risk populations. The methods we describe may be applicable to other populations, settings, and choice contexts in which similar preference heterogeneity is suspected and can serve as a starting point for the systematic design of heterogeneity-focused interventions using stated preference methods.

Acknowledgements

The authors are grateful to the study participants and to the study research assistants, Martha Masaki, Beatrice Mandao, Elizabeth Mbuya, Honoratha Israel, Yombya Madukwa, Mohamed Mcharo, Upendo Nnko, Stephen Sikumbili, Edward Singo, Blandina Zenze, Leonia Rugalabamu, Suzan Kitomari, Stanny Komu, and Beldad Mmari, for input on study procedures and study implementation.

The authors thank the staff of the Kilimanjaro Clinical Research Institute, especially Professor Blandina Mmbaga, Dr. Aisa Shayo, and Zuhura Lintu, the University of South Carolina's Arnold School of Public Health, especially the Department of Health Services Policy & Management and the Center for Health Care Quality, the Duke Global Health Institute and Duke University's Center for Health Policy and Inequalities Research, for administrative support; and members of the Duke Center for AIDS Research and the study's Scientific Advisory Board for feedback on study feasibility, design, analytic methods, and implementation.

Finally, the authors acknowledge Dr. Credianus Mgimba (Regional Medical Officer, Kilimanjaro Region), Dr. Best Magoma (former Regional Medical Officer, Kilimanjaro Region), Dr. Eligy Mosille (Regional AIDS Control Coordinator, Kilimanjaro Region), Ms. Dafrosa Itemba (Director, Tanzania Women Research Foundation), and members of the Moshi District Council administration, for their support of the study's development and implementation.

Funding

Research reported in this publication was supported by the National Institute of Mental Health of the National Institutes of Health in the United States under Award Numbers R01MH106388 and R21MH96631 and by the Duke University Center for AIDS Research (CFAR), an NIH funded program (P30AI064518). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Appendix 1.: Estimates from gender-specific models and strong concordance between class membership predictions from gender-specific vs. aggregate models

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Testing venue								
Home	-1.34	-0.80	-1.03	-2.12	0.36	0.10	-1.81	-0.98
Health facility	1.68	0.54	1.44	0.90	-0.16	0.53	2.77	0.85
Voluntary counseling and testing center	-0.34	0.26	-0.41	1.22	-0.21	-0.63	-0.95	0.12
Testing availability								
Weekdays only	-0.77	-0.84	0.00	-0.14	-0.03	-0.61	-1.57	-0.05
Every day	0.77	0.84	0.00	0.14	0.03	0.61	1.57	0.05
Type of sample								
Arm (venipuncture)	-0.45	0.67	0.65	0.76	-0.35	0.38	2.72	-0.09
Finger (finger prick)	1.68	-0.26	-0.26	-0.28	1.11	-0.31	-1.15	0.51
Mouth (oral swab)	-1.23	-0.41	-0.39	-0.48	-0.76	-0.07	-1.57	-0.43
Additional services								
HIV test only (no additional services)	-1.31	-1.54	-0.87	-1.01	-0.56	-1.04	-2.08	-0.16
Health check	0.82	1.85	0.11	0.53	-0.20	0.89	2.78	0.07
STI examination	0.49	-0.31	0.76	0.48	0.76	0.15	-0.70	0.10
Pre-test counseling and partner notification								
One-on-one counseling; self-disclosure	-0.32	-0.04	0.29	0.73	0.63	-0.32	-0.86	-0.15
Group counseling; self-disclosure	-0.92	-0.67	-0.83	-0.08	-0.59	0.52	-1.16	1.12
One-on-one counseling; provider notification	-0.33	0.43	0.04	-0.08	1.11	-0.61	-1.51	-1.15
Group counseling; provider notification	-0.52	-0.63	-0.77	-0.34	-0.14	0.30	-1.82	-0.32
Couples counseling (automatic disclosure)	2.09	0.91	1.27	-0.23	-1.01	0.11	5.35	0.50

Panel A. Parameter estimates for female barworkers (N = 300).

		Model for female barworkers only (N=300)							
		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
Aggregate model (N=740)	Class 1	3	0	39	9	0	1	2	8
	Class 2	46	3	1	0	1	0	0	1
	Class 3	1	20	0	0	0	0	28	0
	Class 4	2	4	7	22	0	0	0	1
	Class 5	2	0	2	1	28	0	0	7
	Class 6	2	2	2	5	0	17	0	1
	Class 7	0	2	0	0	1	11	0	0
	Class 8	0	18	0	0	0	0	0	0

Panel B. Concordance between class membership predictions from gender-specific (N = 300 female barworkers only) vs. aggregate (N = 740) latent class models.

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Testing venue								
Home	-1.34	-0.80	-1.03	-2.12	0.36	0.10	-1.81	-0.98
Health facility	1.68	0.54	1.44	0.90	-0.16	0.53	2.77	0.85
Voluntary counseling and testing center	-0.34	0.26	-0.41	1.22	-0.21	-0.63	-0.95	0.12
Testing availability								
Weekdays only	-0.77	-0.84	0.00	-0.14	-0.03	-0.61	-1.57	-0.05
Every day	0.77	0.84	0.00	0.14	0.03	0.61	1.57	0.05
Type of sample								
Arm (venipuncture)	-0.45	0.67	0.65	0.76	-0.35	0.38	2.72	-0.09
Finger (finger prick)	1.68	-0.26	-0.26	-0.28	1.11	-0.31	-1.15	0.51
Mouth (oral swab)	-1.23	-0.41	-0.39	-0.48	-0.76	-0.07	-1.57	-0.43
Additional services								
HIV test only (no additional services)	-1.31	-1.54	-0.87	-1.01	-0.56	-1.04	-2.08	-0.16
Health check	0.82	1.85	0.11	0.53	-0.20	0.89	2.78	0.07
STI examination	0.49	-0.31	0.76	0.48	0.76	0.15	-0.70	0.10
Pre-test counseling and partner notification								
One-on-one counseling; self-disclosure	-0.32	-0.04	0.29	0.73	0.63	-0.32	-0.86	-0.15
Group counseling; self-disclosure	-0.92	-0.67	-0.83	-0.08	-0.59	0.52	-1.16	1.12
One-on-one counseling; provider notification	-0.33	0.43	0.04	-0.08	1.11	-0.61	-1.51	-1.15
Group counseling; provider notification	-0.52	-0.63	-0.77	-0.34	-0.14	0.30	-1.82	-0.32
Couples counseling (automatic disclosure)	2.09	0.91	1.27	-0.23	-1.01	0.11	5.35	0.50

Panel C. Parameter estimates for male porters (N = 440).

		Model for male porters only (N=440)							
		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
Aggregate model (N=740)	Class 1	1	44	29	0	0	2	4	0
	Class 2	29	4	18	2	2	3	0	28
	Class 3	0	2	0	9	1	43	1	0
	Class 4	9	22	1	17	2	0	0	0
	Class 5	34	4	9	0	9	0	0	0
	Class 6	0	0	1	4	2	0	38	0
	Class 7	0	0	0	1	39	0	0	1
	Class 8	0	0	0	24	0	1	0	0

Panel D. Concordance between class membership predictions from gender-specific (N = 440 male porters only) vs. aggregate (N = 740) latent class models

Notes: Estimates are based on gender-specific RELCL models with the same specification as the aggregate model presented in Table 2 and Fig. 3. Class membership predictions are based on modal class membership probability.

References



















- Bakk Z, Oberski D, Vermunt J, 2014. Relating latent class Assignments to external variables: standard errors for correct inference. *Polit. Anal* 22 (4), 520–540.
- Beusterien KM, Dziekan K, Schrader S, et al. , 2007. Patient preferences among third agent HIV medications: a US and German perspective. *AIDS Care* 19 (8), 982–988. [PubMed: 17851994]
- Bregigeon-Ronot S, Cheret A, Cabie A, et al. , 2017. Evaluating patient preference and satisfaction for human immunodeficiency virus therapy in France. *Patient Prefer. Adherence* 11, 1159–1169. [PubMed: 28744106]
- Bridges JF, Hauber AB, Marshall D, et al. , 2011. Conjoint analysis applications in health—a checklist: a report of the ISPOR good research practices for conjoint analysis task force. *Value Health* 14 (4), 403–413. [PubMed: 21669364]

- Brown LB, Miller WC, Kamanga G, et al. , 2011. HIV partner notification is effective and feasible in sub-Saharan Africa: opportunities for HIV treatment and prevention. *J. Acquir. Immune Defic. Syndr* 56 (5), 437–442. [PubMed: 22046601]
- Cameron MP, Newman PA, ROUNGPRAKHON S, Scarpa R, 2013. The marginal willingness-to-pay for attributes of a hypothetical HIV vaccine. *Vaccine* 31 (36), 3712–3717. [PubMed: 23747452]
- Cherutich P, Golden MR, Wamuti B, et al. , 2017. Assisted partner services for HIV in Kenya: a cluster randomised controlled trial. *Lancet HIV* 4 (2), e74–e82. [PubMed: 27913227]
- Chiou PY, Lin LC, Chen YM, et al. , 2015. The effects of early multiple-time PN counseling on newly HIV-diagnosed men who have sex with men in Taiwan. *AIDS Behav.* 19 (10), 1773–1781. [PubMed: 25645329]
- d’Elbee M, Indravudh PP, Mwenge L, et al. , 2018. Preferences for linkage to HIV care services following a reactive self-test: discrete choice experiments in Malawi and Zambia. *AIDS* 32 (14), 2043–2049. [PubMed: 29894386]
- Garcia de Olalla P, Molas E, Barbera MJ, et al. , 2015. Effectiveness of a pilot partner notification program for new HIV cases in Barcelona, Spain. *PloS One* 10 (4), e0121536. [PubMed: 25849451]
- Greene WH, Hensher DA, 2013. Revealing additional dimensions of preference heterogeneity in a latent class mixed multinomial logit model. *Appl. Econ* 45 (15), 1897–1902.
- Hauber AB, Mohamed AF, Watson ME, Johnson FR, Hernandez JE, 2009. Benefits, risk, and uncertainty: preferences of antiretroviral-naïve African Americans for HIV treatments. *AIDS Patient Care STDS* 23 (1), 29–34. [PubMed: 19113949]
- Henley C, Forgewei G, Welty T, et al. , 2013. Scale-up and case-finding effectiveness of an HIV partner services program in Cameroon: an innovative HIV prevention intervention for developing countries. *Sex. Transm. Dis* 40 (12), 909–914. [PubMed: 24220349]
- Hess S, 2014. Chapter 14: latent class structures: taste heterogeneity and beyond. In: Hess S, Daly A (Eds.), *Handbook of Choice Modelling*. Edward Elgar Publishing.
- Indravudh PP, Sibanda EL, d’Elbee M, et al. , 2017. ‘I will choose when to test, where I want to test’: investigating young people’s preferences for HIV self-testing in Malawi and Zimbabwe. *AIDS* 31 (Suppl. 3), S203–S212. [PubMed: 28665878]
- Johnson F, Kanninen B, Bingham M, Özdemir S, Bj K, 2007. Experimental design for stated choice studies. In: *Valuing Environmental Amenities Using Stated Choice Studies*. Springer, Dordrecht.
- Johnson FR, Ozdemir S, Phillips KA, 2010. Effects of simplifying choice tasks on estimates of taste heterogeneity in stated-choice surveys. *Soc. Sci. Med* 70 (2), 183–190. [PubMed: 19880234]
- Kahabuka C, Plotkin M, Christensen A, et al. , 2017. Addressing the first 90: a highly effective partner notification approach reaches previously undiagnosed sexual partners in Tanzania. *AIDS Behav.* 21 (8), 2551–2560. [PubMed: 28299518]
- Kruk ME, Riley PL, Palma AM, et al. , 2016. How can the health System retain women in HIV treatment for a lifetime? A discrete choice experiment in Ethiopia and Mozambique. *PloS One* 11 (8), e0160764. [PubMed: 27551785]
- Landis SE, Schoenbach VJ, Weber DJ, et al. , 1992. Results of a randomized trial of partner notification in cases of HIV infection in North Carolina. *N. Engl. J. Med* 326 (2), 101–106. [PubMed: 1445500]
- Mangham LJ, Hanson K, McPake B, 2009. How to do (or not to do) ... Designing a discrete choice experiment for application in a low-income country. *Health Pol. Plann* 24 (2), 151–158.
- Mitchell J, Keane J, Laidlaw J, 2009. *Making Success Work for the Poor: Package Tourism in Northern Tanzania*. Arusha, Tanzania. Overseas Development Institute, SNV Connecting People’s Capacities.
- Mühlbacher AC, Stoll M, Mahlich J, Nübling M, 2013. Patient preferences for HIV/AIDS therapy - a discrete choice experiment. *Health Econ Rev* 3 (1), 14. [PubMed: 23663390]
- Myers RS, Feldacker C, Cesar F, et al. , 2016. Acceptability and effectiveness of assisted human immunodeficiency virus partner services in Mozambique: results from a pilot program in a public, urban clinic. *Sex. Transm. Dis* 43 (11), 690–695. [PubMed: 27893598]
- National AIDS Control Programme, 2017. *Health Sector HIV and AIDS Strategic Plan (HSHP IV) 2017–2022*. Ministry of Health, Community Development, Gender, Elderly and Children.

- National AIDS Control Programme, 2019. In: National guidelines for HIV testing services in Tanzania. Ministry of Health, Community Development, Gender, Elderly and Children.
- Newman PA, Cameron MP, Rongprakhon S, Tepjan S, Scarpa R, 2016. Acceptability and preferences for hypothetical rectal microbicides among a community sample of young men who have sex with men and transgender women in Thailand: a discrete choice experiment. *AIDS Behav.* 20 (11), 2588–2601. [PubMed: 26696260]
- Njau B, Ostermann J, Brown D, Muhlbacher A, Reddy E, Thielman N, 2014. HIV testing preferences in Tanzania: a qualitative exploration of the importance of confidentiality, accessibility, and quality of service. *BMC Publ. Health* 14, 838.
- Ostermann Jan, Mühlbacher Axel, Brown Derek, et al. , 2020a. Heterogeneous patient preferences for modern antiretroviral therapy: results of a discrete choice experiment. *Value in Health.*
- Ostermann J, Njau B, Brown DS, Muhlbacher A, Thielman N, 2014. Heterogeneous HIV testing preferences in an urban setting in Tanzania: results from a discrete choice experiment. *PLoS One* 9 (3), e92100. [PubMed: 24643047]
- Ostermann J, Njau B, Mtuy T, Brown DS, Muhlbacher A, Thielman N, 2015. One size does not fit all: HIV testing preferences differ among high-risk groups in Northern Tanzania. *AIDS Care* 27 (5), 595–603. [PubMed: 25616562]
- Ostermann J, Njau B, Hobbie A, et al. , 2020. Using discrete choice experiments to design interventions for heterogeneous preferences: protocol for a pragmatic randomised controlled trial of a preference-informed, heterogeneity-focused, HIV testing offer for high-risk populations. *BMJ Open* 10 (11), e039313.
- Peaty D, 2012. Kilimanjaro tourism and what it means for local porters and for the local environment. *Journal of Ritsumeikan Social Sciences and Humanities* 4, 1–12.
- Phillips KA, Maddala T, Johnson FR, 2002. Measuring preferences for health care interventions using conjoint analysis: an application to HIV testing. *Health Serv. Res* 37 (6), 1681–1705. [PubMed: 12546292]
- Quaife M, Eakle R, Cabrera Escobar MA, et al. , 2018a. Divergent preferences for HIV prevention: a discrete choice experiment for multipurpose HIV prevention products in South Africa. *Med. Decis. Making* 38 (1), 120–133. [PubMed: 28863752]
- Quaife M, Terris-Prestholt F, Di Tanna GL, Vickerman P, 2018b. How well do discrete choice experiments predict health choices? A systematic review and meta-analysis of external validity. *Eur. J. Health Econ* 19 (8), 1053–1066. [PubMed: 29380229]
- Rosenberg NE, Mtande TK, Saidi F, et al. , 2015. Recruiting male partners for couple HIV testing and counselling in Malawi's option B+ programme: an unblinded randomised controlled trial. *Lancet HIV* 2 (11), e483–491. [PubMed: 26520928]
- Strauss M, George GL, Rhodes BD, 2018a. Determining preferences related to HIV counselling and testing services among high school learners in KwaZulu-natal: a discrete choice experiment. *AIDS Behav.* 22 (1), 64–76. [PubMed: 27853894]
- Strauss M, George G, Mantell JE, et al. , 2018b. Stated and revealed preferences for HIV testing: can oral self-testing help to increase uptake amongst truck drivers in Kenya? *BMC Publ. Health* 18 (1), 1231.
- Tanzania Commission for AIDS, 2018. Tanzania HIV Impact Survey (THIS) 2016–2017: Final Report. Tanzania Commission for AIDS (TACAIDS), Zanzibar AIDS Commission (ZAC). <https://phia.icap.columbia.edu/countries/tanzania/>. Accessed 15-Apr-2021.
- Terris-Prestholt F, Hanson K, MacPhail C, Vickerman P, Rees H, Watts C, 2013. How much demand for new HIV prevention technologies can we really expect? Results from a discrete choice experiment in South Africa. *PLoS One* 8 (12).
- Divergent paths to the end of AIDS. In: *The Lancet* (Ed.), *Lancet HIV* 4 (9), e375.
- Udeagu CC, Shah D, Shepard CW, Bocour A, Guterrez R, Begier EM, 2012. Impact of a New York City Health Department initiative to expand HIV partner services outside STD clinics. *Publ. Health Rep* 127 (1), 107–114.
- Udeagu CC, Bocour A, Shah S, Ramos Y, Gutierrez R, Shepard CW, 2014. Bringing HIV partner services into the age of social media and mobile connectivity. *Sex. Transm. Dis* 41 (10), 631–636. [PubMed: 25211262]

- UNAIDS, 2014. 90–90–90. An Ambitious Treatment Target to Help End the AIDS Epidemic. UNAIDS. Accessed August 7, 2018. http://www.unaids.org/sites/default/files/media_asset/90-90-90_en.pdf.
- United Republic of Tanzania, 2012. Tanzania Population and Housing Census. National Bureau of Statistics. https://www.nbs.go.tz/nbs/takwimu/census2012/Tanzania_Total_Population_by_District-Regions-2016_2017r.pdf. Published 2012. Accessed December 1, 2019.
- Zanolini A, Sikombe K, Sikazwe I, et al. , 2018. Understanding preferences for HIV care and treatment in Zambia: evidence from a discrete choice experiment among patients who have been lost to follow-up. *PLoS Med.* 15 (8), e1002636. [PubMed: 30102693]
- Zhou M, Bridges JF, 2019. Explore preference heterogeneity for treatment among people with Type 2 diabetes: a comparison of random-parameters and latent-class estimation techniques. *Journal of Choice Modelling* 30, 38–49.

1. We would like you to think of three different testing options, alternative A, B and C.

Alternative A	Alternative B	Alternative C
You will test in a Health center 	You will test in a Health center 	You will be tested in your Home 
Testing is available Every day 	Testing is available Weekdays only 	Testing is available Every day 
Pre-test counseling is done One-on-one 	Pre-test counseling is done in a Group 	You are required to come with your partner for pre-test counseling 
The sample is taken from the Finger 	The sample is taken from the Finger 	The sample is taken from the Mouth 
You will be tested for HIV and other illnesses 	In addition to being tested for HIV you will be examined for STIs 	In addition to being tested for HIV you will be examined for STIs 
If you are HIV positive A counselor will contact your partner to test for HIV 	If you are HIV positive A counselor will contact your partner to test for HIV 	If you are HIV positive Your partner will receive the result at the same time 

If today you were given these three options in order to test for HIV, which alternative would you choose, alternative A, B or C?

Fig. 1.
Sample DCE choice task.

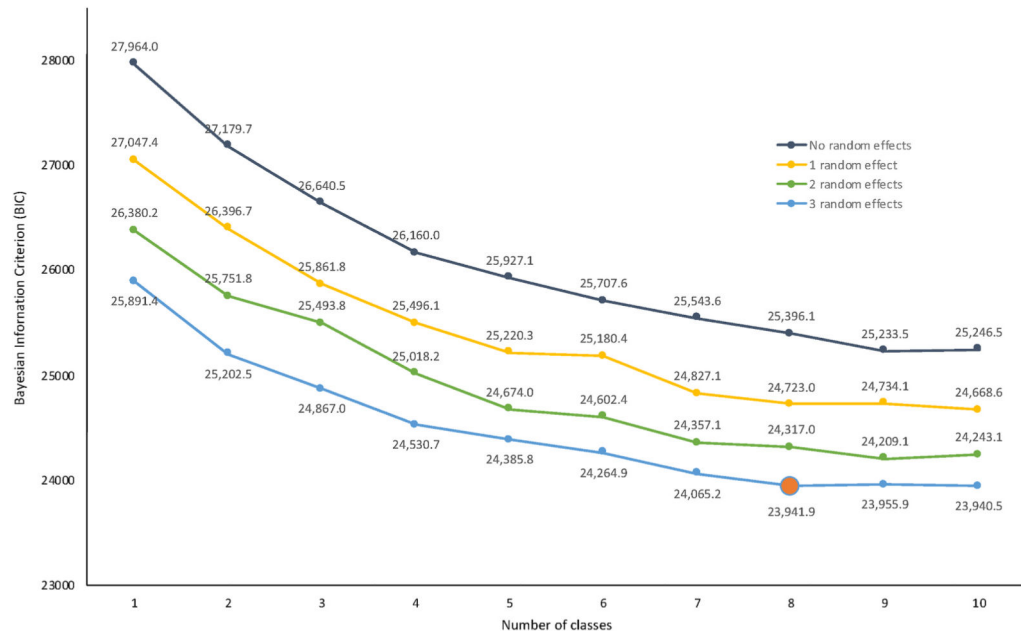


Fig. 2. Relative performance of alternative latent class specifications with 0–3 random effects.

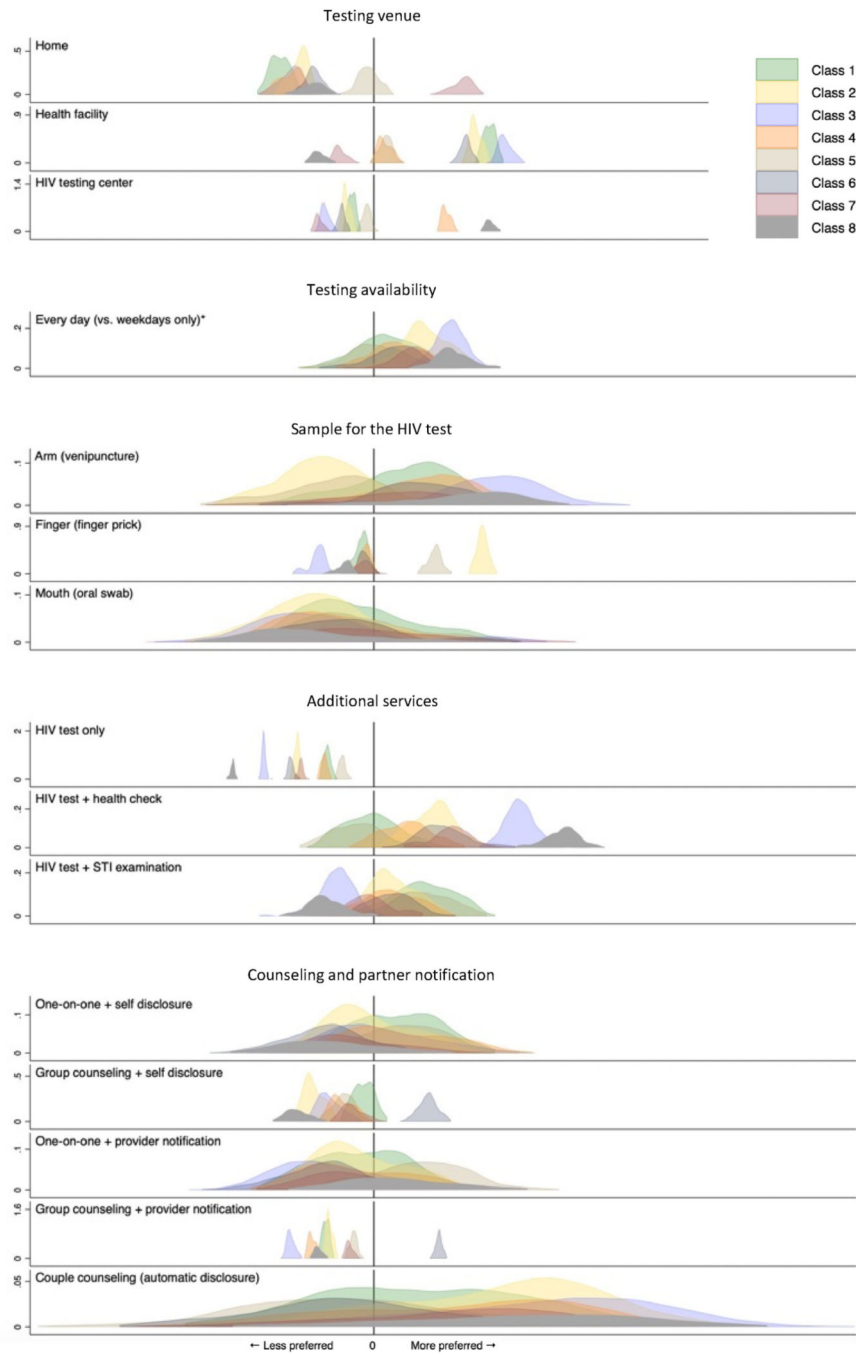


Fig. 3. Visualization of between- and within-class preference heterogeneity; estimates from a random effects latent class logit model (N = 740) Notes: Distributions represent kernel densities of individual-level preference estimates conditional on modal class membership probability and individuals’ posterior scores on three domain-specific random effects. Each color represents one preference class. Within attribute levels, kernel densities were scaled in proportion to class size; y-axis scales vary across attribute levels. * Estimates for the *weekdays only* attribute level are symmetric around $x = 0$. (For interpretation of the

references to color in this figure legend, the reader is referred to the Web version of this article.)

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Characteristics of study participants.

Table 1

	Study sample ^b		National sample ^c	
	(Ages 18–49, urban)		(Ages 18–49, urban)	
	Female barworkers	Male porters	Females	Males
Number of participants	300	440	5067	4077
Age	Mean (sd)	31.4 (6.71)	29.6 (8.4)	29.8 (8.4)
Marital status	Married	65.6%	58.5%	65.9%
	Not married	34.4%	41.5%	34.1%
Education	Primary school or less	55.4%	62.5%	51.8%
	Secondary school	44.6%	37.5%	48.2%
# of HIV tests	None	20.0%	12.3%	26.6%
	1	13.7%	.	.
	2	19.3%	.	.
	3	26.3%	.	.
	4	15.3%	.	.
	5 or more	20.0%	11.4%	.
Most recent HIV test ^a	In the past year	49.4%	50.8%	51.5%
	More than 1 year ago	53.9%	49.2%	48.5%

Notes.

Sample restricted to adults ages 18–49, living in mainland urban Tanzania; <https://phia-data.icap.columbia.edu/files>.

Information not available.

^a Among those who tested at least once.

^b Demographic data (age, marital status, education) are missing for 1 porter and 1 barworker

^c Source: Survey-weighted means and percentages from the 2016–2017 Tanzania HIV Impact Survey (THIS).

Table 2
 Heterogeneous HIV testing preferences: Results from a random effects latent class logit model (RELCL; N = 740).

	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	
Class sizes									
All participants	18.9%	18.7%	13.5%	12.8%	12.5%	10.1%	7.5%	6.1%	
Female barworkers	20.0%	18.0%	15.4%	13.8%	12.6%	9.7%	4.6%	6.1%	
Male mountain porters	18.3%	19.1%	12.2%	12.1%	12.5%	10.3%	9.5%	6.1%	
									Loadings, λ^a
									Class-specific coefficient estimates, β
Testing venue									
Home	-1.34 (0.09)	-1.06 (0.08)	-1.18 (0.09)	-1.19 (0.11)	-0.07 (0.08)	-0.84 (0.09)	1.26 (0.12)	-0.87 (0.13)	-0.168 1
Health facility	1.65 (0.13)	1.45 (0.10)	1.87 (0.12)	0.16 (0.14)	0.17 (0.09)	1.30 (0.11)	-0.48 (0.10)	-0.78 (0.15)	0.103 1
Voluntary counseling and testing center	-0.31 (0.10)	-0.39 (0.08)	-0.69 (0.10)	1.03 (0.17)	-0.10 (0.08)	-0.46 (0.10)	-0.78 (0.11)	1.65 (0.18)	0.065 1
Testing availability									
Weekdays only	-0.15 (0.07)	-0.72 (0.06)	-1.09 (0.08)	-0.35 (0.09)	0.00 (0.07)	-0.33 (0.09)	-0.61 (0.08)	-1.13 (0.13)	0.408 3
Every day	0.15 (0.07)	0.72 (0.06)	1.09 (0.08)	0.35 (0.09)	0.00 (0.07)	0.33 (0.09)	0.61 (0.08)	1.13 (0.13)	-0.408 3
Type of sample									
Arm (venipuncture)	0.50 (0.11)	-0.66 (0.12)	1.45 (0.16)	0.64 (0.19)	-0.55 (0.13)	0.59 (0.14)	0.26 (0.17)	1.29 (0.21)	0.911 2
Finger (finger prick)	-0.17 (0.08)	1.55 (0.10)	-0.81 (0.10)	-0.14 (0.11)	0.87 (0.08)	-0.15 (0.09)	-0.15 (0.09)	-0.42 (0.16)	0.114 2
Mouth (oral swab)	-0.33 (0.12)	-0.89 (0.13)	-0.64 (0.14)	-0.50 (0.22)	-0.32 (0.13)	-0.44 (0.15)	-0.11 (0.18)	-0.87 (0.19)	-1.025 2
Additional services									
HIV test only (no additional services)	-0.66 (0.06)	-1.09 (0.08)	-1.57 (0.11)	-0.71 (0.10)	-0.45 (0.06)	-1.18 (0.09)	-1.04 (0.09)	-2.01 (0.16)	0.049 3
Health check	-0.02 (0.08)	0.87 (0.09)	2.07 (0.15)	0.44 (0.11)	-0.22 (0.08)	0.96 (0.12)	1.10 (0.12)	2.68 (0.22)	0.391 3

	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	
STI examination	0.68 (0.08)	0.22 (0.08)	-0.51 (0.09)	0.26 (0.10)	0.67 (0.09)	0.22 (0.10)	-0.06 (0.10)	-0.67 (0.14)	-0.440 3
Pre-test counseling and partner notification									
One-on-one counseling; self-disclosure	0.32 (0.10)	-0.08 (0.12)	0.07 (0.14)	0.37 (0.21)	0.38 (0.13)	-0.72 (0.15)	-0.30 (0.16)	-0.58 (0.22)	0.735 1
Group counseling; self-disclosure	-0.14 (0.10)	-0.86 (0.10)	-0.63 (0.12)	-0.44 (0.11)	-0.43 (0.10)	0.76 (0.14)	-0.30 (0.13)	-1.09 (0.22)	0.175 1
One-on-one counseling; provider notification	-0.18 (0.12)	-0.22 (0.15)	-0.62 (0.17)	-0.22 (0.24)	0.63 (0.15)	-0.72 (0.18)	-0.25 (0.17)	0.35 (0.26)	0.786 1
Group counseling; provider notification	-0.68 (0.09)	-0.63 (0.09)	-1.18 (0.11)	-0.87 (0.13)	-0.29 (0.10)	0.92 (0.14)	-0.34 (0.11)	-0.79 (0.16)	0.059 1
Couples counseling (automatic disclosure)	0.69 (0.20)	1.80 (0.28)	2.36 (0.30)	1.17 (0.45)	-0.28 (0.26)	-0.24 (0.29)	1.19 (0.29)	2.11 (0.38)	-1.755 1

Notes: Estimates from a RELCL model with 8 preference classes and 3 class-independent random effects.

^a 1, 2, and 3 indicate the corresponding attribute domain: λ_1 – privacy and confidentiality; λ_2 – invasiveness and perceived accuracy; λ_3 – accessibility and value.

Table 3
 Correlates of latent class membership and individual-specific random effects (N = 740).

	Age	Some secondary school education	Married	Tested once	Tested more than once	Male porters
Class 2	-0.08 *** (0.00)	-0.03 (0.05)	0.12 * (0.06)	1.01 *** (0.06)	0.67 *** (0.08)	0.35 *** (0.06)
Class 3	-0.07 *** (0.00)	-0.49 *** (0.06)	0.02 (0.06)	0.88 *** (0.10)	0.62 *** (0.08)	-0.05 (0.06)
Class 4	-0.06 *** (0.00)	-0.29 *** (0.06)	0.10 (0.06)	0.16 (0.07)	-0.21 ** (0.08)	-0.13 (0.07)
Class 5	-0.02 *** (0.00)	-0.09 (0.06)	-0.48 *** (0.07)	0.41 *** (0.09)	-0.03 (0.07)	0.24 *** (0.06)
Class 6	-0.09 *** (0.00)	0.04 (0.07)	-0.13 * (0.07)	0.78 *** (0.11)	0.64 *** (0.08)	0.45 *** (0.06)
Class 7	-0.05 *** (0.01)	-0.23 *** (0.06)	0.09 (0.06)	1.46 *** (0.07)	1.11 *** (0.11)	1.09 *** (0.08)
Class 8	-0.06 *** (0.01)	-0.52 *** (0.08)	-0.42 *** (0.08)	1.51 *** (0.13)	1.16 *** (0.11)	0.39 *** (0.07)
λ_1	0.01 * (0.01)	0.14 * (0.07)	-0.29 *** (0.07)	-0.13 (0.11)	-0.32 ** (0.09)	-0.02 (0.07)
λ_2	-0.01 (0.01)	-0.16 * (0.07)	0.05 (0.07)	0.22 * (0.11)	0.12 (0.10)	-0.09 (0.07)
λ_3	0.00 (0.01)	-0.03 (0.07)	-0.05 (0.07)	0.19 (0.11)	-0.01 (0.09)	0.03 (0.07)

Notes: Coefficients and standard errors for correlates of class membership estimated using a bias-adjusted multinomial logit model; class 1 is the reference class; constants not shown. Coefficients and standard errors for correlates of individual-specific random effects estimated using linear regression models.

*, **, and *** indicate statistical significance at the 0.05, 0.01, and 0.001 levels, respectively.