



Heterogeneity in individual preferences for HIV testing: A systematic literature review of discrete choice experiments

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ABSTRACT

Background: Understanding variations in HIV testing preferences can help inform optimal combinations of testing services to maximize coverage. We conducted a systematic review of Discrete Choice Experiments (DCEs) eliciting HIV testing preference.

Methods: We searched the published literature for papers that conducted DCEs to assess user preferences for HIV testing.

Findings: We identified 237 publications; 14 studies conducted in 10 countries met inclusion criteria. Overall, test cost was one of the strongest drivers of preference, with participants preferring free or very low-cost testing. Confidentiality was a salient concern, particularly among key populations and persons who never tested. Participants in resource-limited settings preferred short travel distance and integration of HIV testing with other services. There was substantial heterogeneity across participant characteristics. For example, while women preferred home testing, high-risk groups (e.g. male porters, female bar workers) and men who had not tested in the last year preferred traveling a short distance for testing. HIV self-testing (HIVST) had high acceptability, particularly among those who had never HIV tested, although most users preferred blood-based sample collection over oral swabs. Participants highly valued post-test counselling availability after HIVST.

Interpretation: Overall, participants value low-cost, confidential testing with short travel distance. HIVST is a promising strategy to increase testing coverage but post-test counseling and support should be made available. Educational campaigns to increase familiarity and build confidence in results of oral testing can improve the success of HIVST. DCEs conducted within clinic settings likely have limited generalizability to those not seeking care, particularly for key populations.

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1. Introduction

HIV testing is the first step to accessing HIV treatment and prevention. However, only 75% of persons with HIV worldwide know their status indicating that expanded testing strategies are needed to achieve the first 95 of UNAIDS' ambitious testing, treatment and viral suppression targets by 2030 [1]. To maximize the potential of antiretroviral treatment (ART) to curb the epidemic, HIV testing services must be tailored to the preferences of those at risk, particularly underserved populations including men, adolescents and young adults (AYA), sex workers, and men who have sex with men (MSM).

Sub-optimal HIV testing rates among these groups suggest that current testing services may not be well-aligned with user preferences [2,3]. Barriers and motivators to HIV testing differ by subgroup and understanding variations in preferences can help inform the optimal combination of HIV testing programs.

Discrete Choice Experiments (DCEs) are well-suited to identify individuals' preferences for HIV testing attributes [4]. Grounded in the economic theory of utility maximization, DCEs enable researchers to describe how individuals value selected features of services by asking them to choose between different hypothetical alternatives [5]. DCEs have become an increasingly popular method of eliciting preferences for healthcare [6]. We conducted a systematic review of DCEs eliciting HIV testing preference to synthesize evidence for stakeholders charged with implementing testing strategies.

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Research in context

Evidence before this study

We searched PubMed for studies published through September 8, 2020 that synthesized the literature on HIV testing preferences using discrete choice experiments (DCEs) using the terms: "discrete choice experiment" or "dce" and "review" and "HIV". We found only one scoping review assessing the use of DCEs in HIV, which included studies up to 2017. The authors found that participants exhibited the strongest preferences for HIV testing location, testing method, accuracy, confidentiality, and cost, but do not elaborate on the details of the studies, main drivers of testing preference, or heterogeneity in preferences among different groups.

Added value of this study

The majority of studies included in our review were published on or after 2017. We find substantial heterogeneity in HIV testing preferences by sub-population assessed. For example, women preferred home testing while high-risk groups (male porters and female bar workers) and men who have not tested in the last year preferred traveling a short distance for testing. This suggests that confidentiality may be a barrier to home testing among some sub-groups. We also find that many DCEs in the literature recruited participants from HIV testing sites or HIV testing clinical trials, which may impact generalizability to populations who are not already accessing care. Household-based sampling was also frequently utilized, which may under-represent men who travel for work. Finally, there was a lack of studies in underserved populations including men, migratory populations, never-testers, female sex workers (FSWs), and persons who inject drugs (PWIDs).

Implications of all the available evidence

Overall, we find that individuals prefer low-cost, confidential services within a short travel distance. There is substantial heterogeneity across populations, suggesting a combination of testing modalities are needed to achieve high coverage. HIVST is a promising strategy to reach underserved groups, but community sensitization and post-test support are necessary to optimize uptake. More DCEs are needed to assess HIV testing preferences outside of clinic and trial settings, particularly among key populations and never testers.

papers were reviewed by both coders; disagreements were adjudicated by reviewing full texts. Details on data extraction and quality review are provided in the **Appendix**.

2.3. Role of funding source

MS received support from The National Institute of Mental Health (NIMH K01MH115789). JO received support from the Australian National Health and Medical Research Council (GNT1104781). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the article.

3. Results

3.1. Study characteristics

Our search resulted in 237 publications, of which 14 met eligibility criteria and were included in the review (Fig. 1). DCEs were conducted in 10 countries; eight in sub-Saharan Africa (SSA), two each in Europe, and Latin America, one in North America, and one in Asia. Populations assessed included MSM, female bar workers, male porters, truck drivers, AYA, and the general population (Table 1). Six studies reported pilot-testing DCEs before administration, which is recommended to ensure participant understanding of the survey. Only five studies reported using an opt-out (no testing) option in their design, which is necessary to assess if individuals would choose not to test over either testing option presented (Table 2).

3.2. Long distance truck drivers

Male long distance truck drivers in SSA are at increased risk for HIV partially due to risk behaviors (multiple partners, purchasing sex, and inconsistent condom use) and low healthcare access [8]. One DCE evaluated testing preferences among long distance truck drivers recruited from roadside wellness clinics who were participating in an HIV testing trial [9]. Cost was the strongest driver of preference, with participants preferring free tests. Participants preferred provider-administered HIV testing over HIV self-testing (HIVST) and a finger-prick over an oral swab. Testing at a roadside clinic was preferred over home or office testing and in-person counselling was preferred over telephone counselling. However, those who had never HIV tested preferred oral testing and telephone counselling. The authors concluded that the existing service model of roadside clinics was well-aligned with user preferences and implementing HIVST was unlikely to increase testing. However, participants recruited into the DCE were already accessing HIV testing at roadside clinics so their preferences may not be generalizable to long distance truck drivers who do not seek clinic-based testing. Further, 92% of the sample had previously HIV tested, so the study was not sufficiently powered to assess preferences in never testers.

3.3. Male Mt Kilimanjaro Porters

Similar to long distance truck drivers, male porters in Tanzania spend long periods away from home and face unstable income cycles. Porters report three-times as many sexual partners as males in the general population [10]. A DCE in Tanzania assessed the testing preferences of porters compared to males in the general population. Results showed that porters preferred testing a short distance from their home over home testing [10]. Porters preferred venipuncture over finger-prick or oral testing and placed more importance on HIV medications being immediately available. Porters most preferred their spouses knowing that they tested. Both males in the general population and porters preferred to test on weekends, although this attribute was the least important of those assessed.

2. Methods

2.1. Search strategy

We conducted a systematic literature review following Cochrane and PRISMA guidelines [7]. A literature search was conducted with the help of a librarian on 11/9/2019. We searched PubMed, EMBASE, and Global Health Database, using MeSH and comparable terms. Studies were eligible for inclusion if they reported user preferences for HIV testing services using a discrete choice experiment/conjoint analysis. We included studies published from the year 2000 onwards to focus on the recent literature on HIV testing preferences. Full search strategy is reported in the **Appendix**.

2.2. Data screening/extraction

M.S. and J.O screened abstracts for inclusion and characterized eligible studies using a standardized extraction form. All included

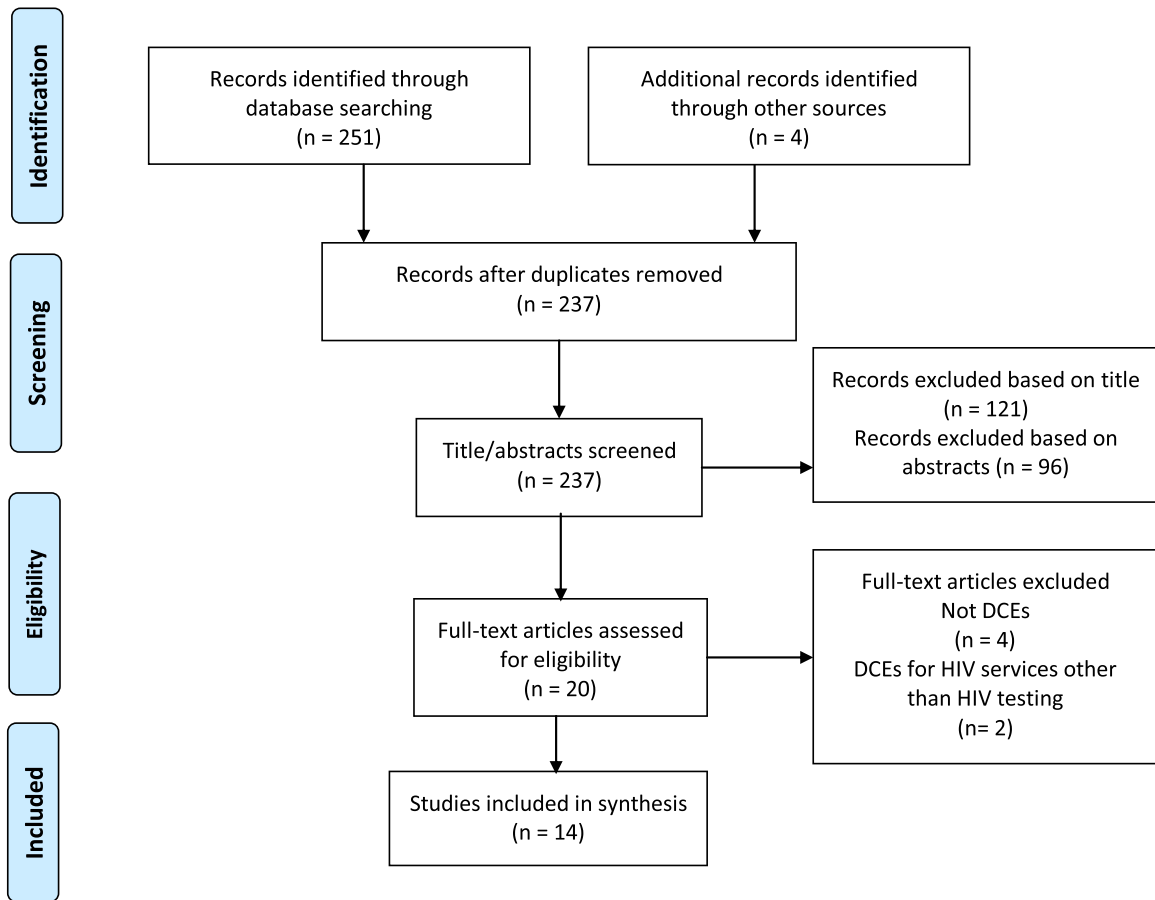


Fig. 1. PRISMA flow diagram.

3.4. Female bar workers

Female bar workers in Tanzania have a high HIV prevalence (19–26%) and twice as many lifetime sex partners as females in the general population [10]. A DCE conducted in Tanzania found that bar workers were more reluctant to test at home and more willing to travel out of town for testing compared to females in the general population [10]. They were more averse than other community members to many people knowing about their HIV test. Similar to porters, they preferred venipuncture over finger-prick or oral swab. Distance to testing was an important driver of preference.

3.5. General population

A DCE in Northern Tanzania using random household sampling found distance was the strongest driver of preference, with home testing most preferred among females and a short travel distance (~1 km) preferred among males [11]. Both sexes preferred their spouses to know about their HIV test, compared to no one knowing, and both preferred finger pricks or venipuncture to oral testing. Both males and females preferred testing in places where medications are available but this was less important than distance and confidentiality. Weekday vs. weekend testing was least important to participants. Stratification by HIV testing history revealed that males who had never tested were more likely to prefer oral swabs and less likely to prefer venipuncture compared to males who had tested previously. Males who had never tested were also more likely to prefer weekend testing. Among females, those who had never tested for HIV preferred that no one know that they tested compared to their spouse knowing. Overall, 67% of the sample consisted of females, as is common with household-based sampling. Therefore, men who travel for

employment and may have higher HIV risk are less likely to be represented.

A second household-based DCE conducted in Zambia assessed preferences for HIVST testing after providing an instructional leaflet and video on HIVST [12]. Participants strongly preferred HIVST over provider-administered testing if post-test counseling was available. The strength of preference for HIVST was slightly stronger among never testers. Participants preferred lower cost self-tests, but never testers were willing to pay more for HIVST compared to previous testers (\$4.60 vs \$3.30USD, respectively). Similar to the DCE conducted in Tanzania, 60% of the sample was female. Generalizability to the target population may have been impacted by the instructional materials which sensitized participants to HIVST and increased their confidence in performing HIVST.

Another household-based DCE evaluated HIVST preferences among participants in the STAR HIVST distribution study in Zimbabwe [13,14]. The strongest preference was free HIVST, and participants preferred home delivery of kits by lay distributors over collection from mobile sites. Men and AYA preferred individual kit distribution rather than kits delivered to whole households. For pre-test support, participants preferred telephone hotline over in-person support or informational leaflet. Preferences for post-test support were not assessed. Only 15% of the sample had never tested for HIV and participants had been provided HIVST kits eight weeks prior to DCE administration which likely limits generalizability to populations who have not received HIVST. Further, the finding that participants preferred home HIVST delivery may have been impacted by their prior experience with this type of distribution.

One DCE conducted in a high resource setting in the USA found that participants valued timely, accurate and confidential testing and most preferred home testing over clinics [15]. This study was

Table 1
Characteristics of studies included^a.

First author & year	Country	Population	Sample size	Inclusion/ exclusion criteria	HIV testing assessed	Sampling strategy	Attributes	Most important preference (s)	Heterogeneity assessed
Bristow et al., 2017	Haiti	General population	298	≥18 years, seeking HIV/STI testing or ANC at clinic	Combined HIV/ syphilis testing	Clinic recruitment	Cost, accuracy, time-to-result, blood draw method, number of draws, and rapid vs laboratory test	Free testing	Non-pregnant and pregnant women, men
Bristow et al., 2018	Peru	MSM and transgender women	347	≥18 years, seeking testing at STI clinic	Combined HIV/ syphilis testing	Clinic recruitment	Rapid vs. laboratory test, cost, potential for false positive syphilis result, time-to-result, blood draw method, number of blood draws	Free testing, no false positive result for syphilis	MSM, transgender women
Indravudh et al., 2017	Malawi and Zimbabwe	Adolescents and young adults (age 15–25)	341	Residing in catchment area, age 16–25 years. In Malawi: no previous HIV+ diagnosis	HIVST	Random household sampling within HIVST trial	Test cost, sample collection method, HIVST or provider-administered, location, pretest support, posttest support, provider type, provider age, provider residence, location, hours, batched or individual distribution	Free testing	Country, HIV testing history
Llewellyn et al., 2013	UK	University students	233	University students, completing online survey	HIV and STI testing	Convenience sample (internet)	Time to appointment, results waiting time, which results provided, staff type, type of STI testing included, method for reporting results	Integrated HIV testing with other STIs (syphilis, herpes)	Age, sex, testing history
Michaels-Igbokwe et al., 2015	Malawi	Adolescents and young adults (age 15–24)	537	Age 15–24 years	Combined HIV testing/family planning	Random selection based on community mapping exercise	Age and sex of provider, confidentiality, availability of HIV services, youth friendly components, price	Confidential testing	Sex, relationship status, age
Miners et al., 2019	UK	MSM	620	≥16 years, no previous HIV+ diagnosis	HIVST, provider HTC	Convenience sample (paid advert on Facebook)	Testing location, sampling method, method of obtaining test, inclusion of testing for other STIs, test accuracy, test cost, infection window period,	Short waiting time	Latent class analysis

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Table 1 (Continued)

First author & year	Country	Population	Sample size	Inclusion/ exclusion criteria	HIV testing assessed	Sampling strategy	Attributes	Most important preference (s)	Heterogeneity assessed
Ostermann et al., 2015	Tanzania	Female bar workers, male porters	162 female bar workers 194 male porters	≥1 lifetime sex partner, no previous HIV+ diagnosis	home and facility HTC	Snowball sampling	waiting time to be seen Distance to testing, confidentiality of testing, weekdays vs. weekend testing, method for obtaining the sample for testing, availability of ART at testing site	Finger prick, short travel distance,	Bar workers, porters compared to general population
Ostermann et al., 2014	Tanzania	General population	486	Residing in catchment area	Facility and home HTC	Household random sampling within HIV Testing Preferences trial	Distance to testing, confidentiality, testing days, method for obtaining sample, availability of ART at testing site.	Home testing, confidential testing	Sex, HIV testing history
Pan et al., 2018	China	MSM	803	MSM, ≥16 years old, no previous HIV+ diagnosis	HIVST, provider HTC	Recruited from gay community organization and gay social network portals	Test location, anonymity, test administrator, disclosure of MSM status, type of test, Cost, appointment necessary	Free testing, anonymous testing	Testing history, age, sexual orientation, income
Phillips et al., 2002	USA	General population	354	Persons attending HIV testing sites	Home and facility HTC	Clinic recruitment	Testing location, test cost, sample collection method, time to result, accuracy, privacy/ anonymity, counseling method	Private/ anonymous testing	Income, sexual orientation, and education
Sibanda et al., 2019	Zimbabwe	General population	296	≥16 years, lived in community for ≥3 months		Random household sampling within HIVST trial	Distribution method, HIVST cost, pretest support, time of operation, distributor age, distributor residence, location of kit collection	Free testing	Age, sex, HIV testing history, religion
Strauss et al., 2018	Kenya	Long distance truck drivers	305	≥18 years, reside in Kenya, no previous HIV+ diagnosis, attending roadside clinics	Clinic HTC and HIVST	Clinic recruitment	Sample collection method, in-person vs telephone counseling, provider-administered vs HIVST, testing location, time needed to test, cost.	Free testing	testing history, sexual behavior
Strauss et al., 2018	South Africa	High school students (age 16+) at	248	≥16 years, attending school	Facility and community HTC	Researchers and teachers	Testing location, person	Free or incentivized testing	

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Table 1 (Continued)

First author & year	Country	Population	Sample size	Inclusion/ exclusion criteria	HIV testing assessed	Sampling strategy	Attributes	Most important preference (\$)	Heterogeneity assessed
Zanolini et al., 2018	Zambia	schools in CAPRISA	1617	age 16–49 years old	HIVST	identified students that would represent random sample	conducting testing, counseling type, sample collection method, days/time testing provided, time needed to test, cost	HIVST (vs. provider testing), counseling available	Age, sex, sexual behavior, testing history, grade
		General population				Random household sampling using census data	Self-testing vs. facility testing, counseling available, location of HIVST pickup, cost of HIVST.		Regular testers and non-regular testers

§ ANC: Antenatal care, STI: sexually transmitted infection, HIVST: HIV self-testing, MSM: men who have sex with men.

conducted in publicly-funded HIV testing locations, therefore may not be representative of persons not seeking testing. Similarly, a DCE conducted among a clinic population in urban Haiti evaluated preferences for dual HIV/syphilis testing [16]. Cost had the highest impact on willingness to test.

3.6. Adolescents and young adults

A DCE conducted in Malawi and Zimbabwe examining AYA's preferences for HIVST delivery strategies *via* household survey and qualitative assessment found high HIVST acceptability [17]. Across settings, test price was an important driver of preference, with very low or no cost HIVSTs preferred. Participants did not reveal a preference for oral vs. blood-based sampling. However, qualitative results revealed concerns about accuracy of oral testing although it was viewed as more convenient. In Malawi, AYA preferred to obtain an HIVST from lay community distributors compared to intimate partners or healthcare providers; in Zimbabwe, distributor type was not assessed but participants were indifferent to provider age and whether they came from the same community. Qualitative results in both countries indicated lack of trust of healthcare providers and preference for home HIVST distribution among AYA. In Malawi, participants preferred in-person post-test counseling to hotline or leaflet support. While this attribute was not assessed in Zimbabwe, qualitative results show the importance of in-person post-test support.

A DCE of provider-administered HIV testing among adolescents in high school (≥ 16 years) in South Africa found cost to be the most important driver of testing preference [18]. Offering a financial incentive of \$7.50 USD had the largest effect on testing, while even a small fee of \$1.50 decreased preference for testing. Boys were more strongly motivated than girls by financial incentives. Participants preferred finger-prick to blood draw or oral sampling and valued in-person counseling. Test administration by a nurse from a neighboring community was preferred over a nurse from the adolescents' community whom they know. Participants showed an aversion to group counseling, with boys showing a greater aversion. This study was conducted in schools offering HIV testing as part of the CAPRISA trial; therefore participants had more HIV testing experience than adolescents in the general population.

A DCE evaluating a combined package of family planning and HIV testing services in Malawi showed that AYA valued confidentiality and onsite availability of ART [19]. Respondents were less likely to choose a service with older providers (≥ 30 years old) and preferred lower cost services. Similar to the DCE among high school students in South Africa, males valued confidentiality more than females, although it was an important driver of preference for both sexes. Males were more likely to prefer the addition of youth friendly components such as sports or health talks.

One study of AYAs was conducted in a high resource setting [20]. The authors administered an online DCE to university students in the UK on preferences for sexually transmitted infection (STI) testing. Among this convenience sample, respondents reported a strong preference for integration of STI testing, including HIV, syphilis, and herpes administered by a provider with specialist STI knowledge. Participant's age, sex, or STI testing history was not associated with preference, although the sample size was not large enough to assess heterogeneity.

3.7. MSM

Our search identified three DCEs of HIV testing preferences among MSM, conducted in the UK, China, and Peru [21–23]. Notably, we did not find any studies evaluating preferences of MSM in SSA. One study administered an online DCE to MSM recruited from a social media platform in the UK [21]. The authors investigated preferences for provider-administered testing vs remote testing (defined as HIVST or

Table 2
Quality indicators of studies included⁸.

First author & year	Country	Population	Attribute selection	DCE pilot tested	Opt out option available	Generalizability	Acceptance rate
Bristow et al., 2017	Haiti	General population	Not reported	Not reported	Not reported	Low: participants recruited from clinics, many were seeking STI testing	Not reported
Bristow et al., 2018	Peru	MSM and transgender women	Not reported	Not reported	Not reported	Low: participants were seeking care at STI clinics	Not reported
Indravudh et al., 2017	Malawi and Zimbabwe	Adolescents and young adults (age 15–25)	Literature review, IDIs, FGDs, ranking exercise	Yes	Yes	Medium: participants shown HIVST demonstration which increases familiarity compared to target population, participants in Zimbabwe received HIVST distribution before DCE	Not reported
Llewellyn et al., 2013	UK	University students	Literature review and FGDs	Not reported	Yes	Medium: convenience sample recruited from university website	Not reported
Michaels-Igbokwe et al., 2015	Malawi	Adolescents and young adults (age 15–24)	Literature review, IDIs, FGDs, choice mapping	Yes	No	High: participants randomly selected within villages and repeatedly contacted for enrollment	86%
Miners et al., 2019	UK	MSM	FGDs	Not reported	Yes	Medium: participants had high levels of education and were >90% White	Not reported
Ostermann et al., 2015	Tanzania	Female bar workers, male porters	Literature review, IDIs, FGDs, ranking exercise	Yes	No	Medium: difficult to ascertain representativeness of snowball sampling	Not reported
Ostermann et al., 2014	Tanzania	General population	Literature review, IDIs, FGDs, ranking exercise	Yes	No	Medium: Men who work long hours or travel for work were under-represented by household sampling	79%
Pan et al., 2018	China	MSM	Literature review, FGDs	Yes	Yes	Medium: sampling not likely to reach MSM not opening attending gay venues/networking portals	
Phillips et al., 2002	USA	General population	Literature review, FGDs	Yes	No	Low: participants were recruited for HIV testing sites and had higher education levels than the general population	96%
Sibanda et al., 2019	Zimbabwe	General population	Literature review and FGDs	Not reported	No	Medium: households received HIVST distribution 8 weeks before DCE which could impact their testing preferences	90%
Strauss et al., 2018	Kenya	Long distance truck drivers	Not stated	Not reported	No	Low: participants were recruited from roadside clinics and were	Not reported

(continued)

Table 2 (Continued)

First author & year	Country	Population	Attribute selection	DCE pilot tested	Opt out option available	Generalizability	Acceptance rate
Strauss et al., 2018	South Africa	High school students (age 16+) at schools in CAPRISA	FGDs, literature review, ranking exercise	Not reported	Not reported	enrolled in HIV testing trial Medium: recruitment from schools participating in HIV trial with high HIV testing experience and uptake	Not reported
Zanolini et al., 2018	Zambia	General population	Discussions with in country stakeholders	Not reported	Yes	Medium: participants given instructional leaflet and video on HIVST which increased familiarity compared to target population. 60% of sample was female	85%

[§] STI: sexually transmitted infection, FGD: focus group discussion, IDI: in-depth interview, HIVST: HIV self-testing, MSM: men who have sex with men; HTC: HIV testing and counselling.

self-sampling and mailing of sample to a laboratory). Remote testing preferences included higher test accuracy, shorter window period, and faster results, and oral swab (vs. finger prick). Test cost was the largest barrier to remote testing; free instead of £30 kits was the largest predictor of testing choice. Latent class analysis revealed two groups: 86% of the sample preferred provider-administered HIV testing and 14% preferred remote testing. The group favoring remote testing was more likely to be non-White and never previously HIV tested. The authors concluded MSM generally prefer face-to-face testing compared to self-testing strategies but remote testing has the potential to increase uptake in a subset of MSM. The main limitation was the use of a convenience sample which makes generalizability difficult to ascertain. Although the response rate among persons who saw the advert cannot be assessed, only 50% of those who started the survey completed all DCE questions. Those who did not complete questions were more likely to have lower education and have never HIV tested. This may indicate difficulty understanding the DCE among those with lower education. Further, the sample was 93% White and 3% Asian; only 1% of the sample was Black (seven participants).

A DCE in China recruited men from gay community-based organizations and gay networking portals [22]. Recruitment quotas were used to ensure adequate representation across income, education, and status disclosure to healthcare worker. Cost was the strongest driver of preference. Participants most strongly preferred free, anonymous testing administered by a health care provider. Testing location was of moderate importance. The relative importance of attributes was similar between men with different HIV testing histories. However, never testers most preferred home-based testing and least preferred health department testing while the opposite was true for men who tested previously. Interestingly, men most preferred testing provided by a trained healthcare worker over a lay counselor or self-testing as long as anonymity was preserved. This study was conducted in an urban city and may not generalize to rural locations or other cities in China. In addition, the sampling strategy likely did not reach MSM not openly connected with gay organizations.

Finally, a DCE in Peru evaluated preferences for dual HIV/syphilis testing among MSM and transgender women [23]. Participants were recruited from STI clinics providing services to gay men and transgender women. Participants had the strongest preference for high syphilis test accuracy and free testing. No significant differences in

testing preferences were observed between MSM and transgender women. Participants were seeking testing at clinics so their preferences may not generalize to those not accessing care.

4. Discussion

Across studies, cost was one of the strongest drivers of preference, with participants preferring free or very low cost testing. This suggests that even in high-income settings, HIV test cost can be significant barrier to testing. Confidentiality was also a salient concern, particularly among key populations and never testers. HIV-related stigma can deter individuals from testing, especially in clinics where they may be seen by others in their community [24]. Further, lack of confidence in healthcare providers to maintain confidentiality is a barrier to testing. A DCE of AYA in Malawi found that participants preferred obtaining an HIVST from a lay distributor over a healthcare worker, and study among South African high school students showed that participants preferred HIV testing administered by nurses from neighboring communities instead of their own community [17,18]. Finally, a study in China showed that MSM preferred anonymous testing to providing their names to providers [22]. This is consistent with qualitative findings that show perceived health workers' inability to maintain confidentiality and fear of HIV-related stigma are major barriers to testing [25]. Fear of losing social capital, particularly from one's spouse, family or community, can generate fear of learning one's status, especially in settings of high poverty [26]. Community awareness campaigns emphasizing the ability of ART to restore one's health and prevent onward transmission can reduce HIV-related stigma [27]. Provider training can improve attitudes towards HIV testing and confidentiality of services. Integration of HIV testing with other services including STI testing, family planning, or youth friendly activities can normalize testing and was preferred in the DCEs in our analysis.

There was substantial heterogeneity in preferences across populations. For example, while home HIV testing was preferred by women in the general population, high risk groups (e.g. male porters, female bar workers) and men who had not tested in the last year preferred to travel a short distance for testing [10]. Further, a DCE in Tanzania noted that while home testing was preferred on average by women, a large standard deviation around this parameter suggests that a sizeable proportion of women derived a negative utility from home testing [11]. A study of MSM in China found those who had previously tested preferred facility over home testing, while never testers

preferred home testing [22]. Although, home testing is most convenient in terms of travel time, confidentiality may be a concern, particularly among individuals worried about testing HIV-positive. Fear of disclosure to others in the household may be a barrier to home testing. For example, female bar workers in Tanzania preferred that their partner does not know about their HIV test [10]. Similarly a DCE in Zimbabwe found that men and AYA preferred individual HIVST distribution to batched distribution (kits provided to the whole household). This may indicate concerns about confidentiality or coerced testing by others in the household. Travel distance to HIV testing was another source of heterogeneity. Overall, participants preferred shorter travel distances to testing services, indicating opportunity costs associated with travel time and transport costs can be a barrier to testing. However, female bar workers and male porters were more willing to travel longer distances for testing, suggesting that the convenience of closer testing may be outweighed by confidentiality concerns of testing in one's own community [10]. Together, these results suggest that while home testing has high acceptability, it is not universally preferred. To reach the first 95 of UNAIDS ambitious targets, policymakers must implement a combination of HIV testing strategies that fit the diverse preferences of different sub-populations.

HIVST is a promising strategy to overcome barriers associated with provider-administered testing including confidentiality concerns, stigma, and opportunity costs of travel and waiting. HIVST can increase testing coverage, particularly among key populations and never testers [12,21]. Overall, studies show participants prefer free or very low cost HIVST. However, a DCE conducted in Zambia found never testers had a slightly higher willingness to pay for HIVST compared to those who previously tested [12]. HIVST had high acceptability in a study of AYA in Malawi, with participants preferring distribution from lay counselors over intimate partner or healthcare workers [17]. A study of MSM in the UK found that while most men preferred provider-administered testing, a subset of participants who were more likely to be never-testers and non-White, preferred self-testing [21]. A study of MSM in China found that participants preferred HIVST, mainly due to confidentiality of services, but only in the absence of anonymous provider-administered testing [22]. Across studies, participants strongly valued availability of post-test counseling. Qualitative studies highlight participant fears about self-testing HIV-positive in the absence of counseling support, including depression, failure to link to ART, and even suicide [28]. HIVST strategies should incorporate in-person or hotline support to provide counseling and encourage individuals to link to ART or prevention [29]. Similarly, pre-test support (instructional leaflet, video, or hotline) can increase individuals' confidence in conducting testing and interpreting results. Concerns about HIVST accuracy are frequently cited as a barrier to uptake, with individuals expressing doubt that a saliva-based test can detect a virus found in the blood [28]. DCEs among the general population, long distance truck drivers, male porters, and female bar workers show that participants prefer finger prick or venipuncture over oral testing, which may be driven by misinformation regarding reliability of oral swab testing [17]. As HIVST is scaled-up, community sensitization and awareness campaigns emphasizing test accuracy and explaining HIVST use may increase acceptability [30]. Interestingly, a DCE in Tanzania found while blood-based sampling was preferred by the general population, males who have never tested preferred oral swabs. This suggests that HIVST may overcome barriers such as fear of needles and increase HIV testing coverage among under-served groups, including men.

A significant limitation of several studies we assessed is generalizability to the population of interest. Four of the 14 DCEs recruited participants from STI clinics, most of whom were seeking HIV testing. For example, a study in Kenya that enrolled long distance truck drivers from roadside clinics found that services provided were well-aligned with participant preference and HIVST distribution was unlikely to increase testing coverage [9]. This result is not surprising

given the men in the study were seeking HIV testing at a clinic. Further, their preferences are unlikely to generalize to truck drivers not accessing clinic testing likely due to differences in testing preferences. Two DCEs assessed utilized convenience samples, making generalizability difficult to determine. A study of MSM recruited from a social media platform in the UK found that most men preferred standard-of-care clinic testing [21]. However, over 90% of the sample was White, half had a college degree or higher, and 80% had tested for HIV in the past. Further only 50% of those who started the survey completed it, and those who did not complete it were more likely to be never testers and have lower education. It is likely that the preferences of highly educated, White MSM do not generalize to other subgroups of MSM, who may be less comfortable accessing the health system. Indeed, if current testing modalities were well-aligned with the preferences of key populations, HIV testing rates would likely be higher in these groups. Although it is difficult to obtain representative samples of key populations, studies using snowball or venue-based sampling may have greater generalizability. In addition, four DCEs utilized household-based surveys; over 60% of the samples were female suggesting then men who work long hours or travel for employment may be missed. These men likely have distinct HIV testing preferences due to their mobility and may be less likely to access clinic testing. Further, several studies recruited participants from HIV testing or HIVST trials or provided instructional materials on HIVST use prior to DCE administration. Lack of familiarity with HIVST may be a barrier to acceptability so participants who receive information on HIVST may no longer be representative of the target population. Most participants recruited from HIV testing trials had already demonstrated willingness to test using existing strategies so their preferences may not be generalizable to the rest of the population. Additionally, acceptance rate is an important indicator of generalizability—low acceptance overall or among subpopulations could indicate selection bias, as those willing to complete a DCE about HIV testing may have different preferences than those who decline. Only four studies reported acceptance rates [11,13,15,19]. Further, although there was substantial heterogeneity in testing preferences, many studies were not powered to detect differences among subpopulations. Finally, there was a lack of studies in underserved populations including men, migratory populations, never-testers, female sex workers (FSWs), and persons who inject drugs (PWIDs). We found no DCEs among MSM in SSA and only one clinic-based DCE among transgender women [23]. Globally, over half of new HIV infections occur in key populations and MSM, FSWs, and PWID have >20-times the HIV risk of the general population [31]. With effective scale-up of ART, the epidemic is increasingly concentrating among key populations and assessing their HIV testing preferences is critical to informing prevention. Finally, our search yielded only 14 studies so our conclusions are limited by the small number of papers included.

We synthesized the literature on HIV testing preferences to provide an overview of attributes influencing HIV testing acceptability. Overall, individuals prefer low-cost, confidential services within a short travel distance. There is substantial heterogeneity across populations, suggesting a combination of testing modalities are needed to achieve high coverage. HIVST is a promising strategy to reach underserved groups, but community sensitization and post-test support are necessary. More DCEs are needed to access HIV testing presences outside of clinic and trial settings, particularly in key populations and never testers.

Declaration of Competing Interest

Dr. Sharma reports grants from The National Institute of Mental Health during the conduct of the study. Dr. Celum reports grants from The National Institutes of Mental Health during the conduct of the study and personal fees from Merck and Gilead Sciences outside

the submitted work. The other authors declare that they have nothing to disclose.

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Author's contributions

MS and FTP conceived of the analysis and conducted the literature search. MS and JO completed data abstraction. MS wrote the first draft of the paper. All authors critically reviewed the manuscript and approved the final version.

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Data sharing statement

All data utilized in this systematic review are published and publicly available.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2020.100653.

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