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HIV testing intervention development among men who have sex with men in the developed world

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Abstract. HIV testing is a ‘gateway’ technology, enabling access to treatment and HIV prevention. Biomedical approaches to prevention, such as pre-exposure prophylaxis and treatment as prevention, require accurate and regular HIV test results. HIV testing also represents a powerful ‘teachable moment’ for behavioural prevention. An increasing range of HIV tests and the emergence of self-managed diagnostic technologies (e.g. self-testing) means there is now considerable diversification of when, where and how results are available to those who test. These changes have profound implications for intervention development and, indeed, health service redesign. This paper highlights the need for better ways of conceptualising testing in order to capitalise on the health benefits that diverse HIV testing interventions will bring. A multidimensional framework is proposed to capture ongoing developments in HIV testing among men who have sex with men and focus on the intersection of: (1) the growing variety of HIV testing technologies and the associated diversification of their pathways into care; (2) psychosocial insights into the behavioural domain of HIV testing; and (3) better appreciation of population factors associated with heterogeneity and concomitant inequities. By considering these three aspects of HIV testing in parallel, it is possible to identify gaps, limitations and opportunities in future HIV testing-related interventions. Moreover, it is possible to explore and map how diverse interventions may work together having additive effects. Only a holistic and dynamic framework that captures the increasing complexity of HIV testing is fit for purpose to deliver the maximum public health benefit of HIV testing.

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Introduction

We propose that HIV testing has become the central health technology for HIV prevention for both those testing positive and negative. Pre-exposure prophylaxis (PrEP) and wider treatment as prevention (TasP) highlight the growing challenges of understanding the relationship between condom-less sex and HIV transmission risk. The value of condom use as the primary focus of prevention and behavioural surveillance is rapidly diminishing, particularly in countries where PrEP is available. We suggest that HIV testing now supersedes condom use as the behavioural focus of future HIV prevention interventions among men who have sex with men (MSM) in the developed world. Testing presents a relatively future-proof ‘common denominator’ in an ever-diversifying portfolio of prevention approaches implemented in different ways across national settings. HIV prevention approaches that rely on HIV testing range from PrEP (which requires accurate and regular HIV testing), across the cluster of behavioural interventions based around serostatus (including serosorting and partner notification interventions), to more psychological interventions in which testing may represent a ‘teachable moment’ (by using HIV status

to galvanise the adoption and commitment to behaviour change).¹ Wherever treatments are widely available, HIV incidence is likely to be driven by the undiagnosed fraction of people living with HIV, and most HIV morbidity and mortality is increasingly associated with late diagnosis.^{2,3} There is a growing need to recognise the central part HIV testing plays in diverse prevention interventions.

Because HIV testing sits at the nexus of a range of approaches to prevention and care, it has been the focus of both increased international scrutiny⁴⁻⁶ and product development within the commercial sector. At its core, all HIV testing remains fundamentally concerned with diagnosis (for an overview of the function of HIV testing, see Table 1). However, recent innovations have focused on developing diversity in the processes that accompany this central diagnostic function. Variations, for example, in the ability to detect recently acquired infections, who administers the test, how long to wait for the test results, the ways in which test results are delivered and the combination of other tests that may accompany the HIV test (e.g. tests for other sexually transmissible infections (STI) and blood-borne viruses (BBV)). Perhaps associated with the focus on HIV

Table 1. Aims and effects of increasing uptake of HIV testing

ARVs, antiretroviral drugs; PrEP, pre-exposure prophylaxis; STI, sexually transmissible infection; PEP, post-exposure prophylaxis; BBVs, bloodborne viruses

Diagnostic function	Individual health benefits		Public health benefits	
	Mechanism	Gain	Mechanism	Gain
User tests HIV positive	1. Early access to treatment and care	Better health outcomes	Cost-effectiveness	Reduced health expenditure
	2. ARVs reduce viral load	Better health outcomes	Reduced risk of onward transmission	Fewer new infections
	3. Awareness of HIV-positive status	Ability to adopt safer sex practices, such as serosorting	Opportunity to protect future partners (e.g. PrEP, condoms, PEP)	Fewer new infections
	4. Opportunity for partner notification	Reduced STI infections	Opportunity to protect exposed HIV-negative partners (e.g. PEP and future PrEP, condoms)	Fewer new infections
	5. Access to behavioural prevention		Co-infection with STIs and/or BBVs	Identification of partners at risk for prevention interventions Fewer new infections
User tests HIV negative	Opportunity for interventions to reduce future risk (e.g. behavioural, PrEP, condoms)	User remains HIV negative Reduced STI infections	Reduced risk of acquisition	Identification of partners at risk for prevention interventions Fewer new HIV infections Fewer new STI/BBV infections

testing as a preventative technology, and in relation to the economic context of HIV service delivery in much of the developed world, there has also been a marked turn towards the self-management of HIV testing in recent years (e.g. self-testing and self-sampling).

These approaches differ in that in self-testing the testee receives and interprets the results themselves in minutes of testing themselves. In contrast, in self-sampling, the testee collects their sample but then sends the kit away to another setting, where a professional interprets the results and contacts the testee with their test results some time later. This move to self-managed testing has happened at the same time as notable historical and cultural shifts in both the economic context of much of the developed world and in the mediation of the sexual culture of MSMs away from solely physical worlds to embrace intersections with the digital world (e.g. the availability of the test through Internet sites or mobile phone apps).⁷ In this way, testing interventions in general, and self-managed testing interventions in particular, are increasingly being delivered online and outwith traditional ‘bricks and mortar’ services. In many national contexts, from the perspectives of those who are testing, direct contact with health professionals administering the test or sharing test results is reducing.

Over the short history of the HIV epidemic, many different disciplines have focused on HIV testing, highlighting considerable behavioural, social and historical variation. Since effective antiretroviral therapies have become available, there has been a shift in thinking of the HIV test as a relatively infrequent, one-off event, perhaps confirming suspected HIV status, to ideas associated with the HIV treatment cascade and getting people living with HIV on treatment as quickly as possible to minimise harm to their immune system and reduce population viral load.⁸ Equally, since the ‘normalisation’ of HIV testing⁹ there has been a change in considering those who test frequently from being pathological ‘repeat testers’ (with pejorative associations and assumptions relating to ongoing problematic behaviour)

to focusing more on the salutogenic aspects of those people who test regularly. People who test regularly minimise HIV transmission risk and their accurate test results scaffold biomedical approaches such as PrEP.

In light of these technological, social and historical changes and the profusion of technologies, choices, processes and behaviours associated with HIV testing, we believe it is no longer useful to talk about HIV testing interventions or HIV testing policy in any unitary or simplistic fashion. There will be no single testing intervention that represents a panacea to the ongoing problems of HIV prevention in any single population, such as MSM. It is highly likely that multiple testing interventions, delivered simultaneously to different sub-populations at different times, may offer the most sustainable and effective ways of preventing HIV transmission. There is a growing need for clarity and shared language in thinking about HIV testing and to acknowledge the increasing heterogeneity of testing. We believe that in order to deliver the best of what HIV testing can offer to HIV prevention, we need to understand HIV testing in multidimensional ways that capture key differences in technology, behavioural domain and population. In this way it is possible to consider the tailoring and targeting of diverse HIV testing interventions enabling much better purchase on issues such as effectiveness and cost-effectiveness. In this way, further clarity regarding the heterogeneity of HIV testing interventions will enable us to develop cumulative knowledge and make more use of existing evidence.

Growing variety of HIV tests and the diversification of pathways into care

The first commercially available HIV test, an ELISA test, entered the market in 1985. It was a blood-based test that often took 2 weeks before results were available. Because no effective treatment existed, all testing was accompanied by extensive pre- and post-test counselling and was conducted

primarily in the domain of HIV 'specialist centres' or blood banks. Although identifying primary HIV infection was not a prime focus then, the window period, the term given to the maximum time between HIV virus acquisition and the ability of the test to detect the infection, would have been 3 months. Since then, the implications of a positive diagnosis have changed dramatically, and that, coupled with the expansion of testing modalities, has enabled HIV testing to move beyond the remit of specialists into the broader health community and, finally, directly into the control of the end user.

Table 2 provides an overview of the increasingly diverse range of tests currently available and many of their key features. There are now a range of ways that specimens can be collected (e.g. self-testing, point of care, self-sampling and phlebotomy). Different HIV tests have different types of diagnostic properties and can be delivered within an increasing range of settings. The scale-up of testing beyond traditional healthcare settings has been evolving from solely being offered within traditional

testing services to a wider range of settings (e.g. within community settings or sex-on-premises testing sites). This trend of increasing testing sites has been further expanded following recognition of the key role undiagnosed infection has in potentiating HIV transmission¹⁰ and because biomedical prevention interventions have been shown to be so effective.⁸ International findings suggest linkage to care may be influenced by site of diagnosis, with people testing positive in the community setting, as opposed to clinic and other formal healthcare settings, being less likely to be linked into and retained in care.¹¹ In the UK, preliminary data from the national self-sampling pilot suggest that only 77.4% of people with reactive tests are linked to care for confirmatory testing.¹² The relative benefit of these innovations (in that they may reach new populations) is offset by higher attrition in the cascade of care. Equally, the psychological impact of living with an incorrectly assumed HIV-positive status is unknown and, for positive people who do not start treatment, there are

Table 2. Overview of the diversity of HIV tests and their characteristics
SMS, short message service; n/a, not applicable; NHS, National Health Service

	Self-testing	Point of care	Self-sampling	Phlebotomy
Time from test to patient receiving results	15 min	1–15 min	2 days–1 week (postal dependent)	Hours to several days
Characteristics of test result delivery	Instant (read by user)	Instant (delivered by healthcare worker)	Negative results via SMS or secure login Reactive tests via telephone call	Depends on setting Negative: via SMS, telephone or face to face Reactive: via telephone call or face to face
Sample (blood saliva)	Blood or saliva	Blood or saliva	Blood (TDL TINIES™ vial or blood spot) or saliva ^A	Blood
Window period ^B	3 months because all tests are currently third generation only	4–12 weeks	4 weeks unless saliva (then 12 weeks)	2 days–4 weeks
Antibody	12 weeks	12 weeks	12 weeks (when saliva used)	n/a
Antibody and antigen	n/a	4 weeks	4 weeks	4 weeks
RNA	n/a	n/a	n/a	2 days
Resources required for services	Not legally available in some national contexts (e.g. in UK, not available on NHS) Cost of confirmatory testing and linkage to specialist care	Staff training Testing (average ~5 min) Result notification Confirmatory testing	Cost of kit Distribution Laboratory processing Result notification Linkage for confirmatory testing	Staff training Drawing of sample Laboratory processing Result notification
Physical setting of use	User choice	Typically sexual health clinics, community outreach, some primary care services	User choice	Any healthcare setting, typically primary care and hospital
Overt linkage pathways into care and surveillance	No, but information to facilitate process can be incorporated into kits Difficult to monitor testing frequency, or linkage into care	Yes	All those with reactive results would be contacted and offered facilitated linkage for confirmatory testing	Yes

^AIn the UK, only blood-based assays have a Conformité Européenne mark; this does not include the use of dried blood spots.

^BThe window period will vary according to whether the test detects antibodies, antigens or nucleic acids and can range from as little as 48 h (RNA-based tests) to 3 months (tests detecting HIV antibodies only).

ongoing risks to their own health and increased risks of onwards transmission.

Testing options accessible via the Internet may be cheaper to provide and, from the testee's perspective, may avoid the need to access sexual health services, which can be inconvenient and stigma laden. Equally, the use of any face-to-face testing service may raise fears around confidentiality for some MSM who may not have disclosed their sexual conduct with other men to a healthcare professional. Similarly, digital options to access testing will be avoided by those who value the more holistic care received via face-to-face interventions (see below). Service providers also value choice, and the range of testing modalities enables provision of tests best suited to their practice and the presentation of individual cases. Point-of-care tests are used routinely in sexual health services, but primary care clinicians may feel they lack the infrastructure or service flexibility to manage the unexpected reactive results and instead prefer methods where they have more control of when and how to deliver results. Currently in the UK, the only self-managed testing options on the market are third-generation tests that are less suitable for detecting recently acquired infections than fourth-generation tests, which are not available through self-managed routes. For MSM, this current state of affairs limits the usefulness of self-testing in diagnosing very recent infection.

Psychosocial insights into the behavioural domain of HIV testing

There have been problems with attempts to synthesise evidence regarding the role of HIV testing in relation to risk behaviour, with inconsistent accounts of the relationship between testing and sexual behaviour change.^{10,13} Arguably, these problems relate primarily to a lack of attention to the historical, social and psychological heterogeneity of HIV testing behaviours and a rather unitary focus on the test's diagnostic function. At the population level, in many countries HIV testing has changed over time, with increases reported particularly among high-risk populations, such as MSM.^{14,15} These trends reflect changes in the meaning of HIV testing, for example in light of antiretroviral therapy (ART) and PrEP. Currently, for example, people may seek HIV testing in order to access treatment for HIV infection or, conversely, to access PrEP to avoid HIV infection. Equally, more psychologically, for the individual, across their life span and in relation to their sexual careers, HIV testing can mean very different things. Deeper understandings of the behavioural domains of HIV testing (e.g. the range of testing behaviours and their associated antecedents) and specificity in relation to measuring HIV testing (e.g. how often and for what reason) may enable more useful attempts to build cumulative knowledge in relation to HIV testing in order to develop new conceptual and analytical approaches to data analysis, evidence synthesis and future intervention development. In the sections below and within Table 3 we explore, from a psychological perspective, the importance of the psychosocial, technical and temporal context of HIV testing.

Psychosocial context of HIV testing behaviours

Understanding and responding to the psychosocial aspects of HIV testing are vital to develop a range of behavioural

interventions in the future. In the UK, for example, on a population level HIV risk perception is low. Most people who perceive themselves as at risk of HIV have not recently tested, including MSM.¹⁶ Population-level social epidemiology regarding HIV testing, with its focus on population means, fails to appraise the heterogeneity of testing from the perspectives of those seeking, or indeed being offered, a test. For the individual person seeking an HIV test there are differences in the meaning of 'HIV testing' depending on their perception of the likelihood, and the implications of, a positive diagnosis for them at that time in their life. Fear of a positive test result remains a major barrier to seeking HIV testing and this is patterned by perceived likelihood of positive results.¹⁷ Testing following a perceived risk event, for example, is considerably different from testing that is regular or habitual. It may present very different psychological processes than those that preceded an individual's previous HIV tests. Testing that was initiated by a health professional, for example, may have required little conscious thought or decision making for the person getting tested. Increasing testing such as this can be achieved through interventions that focus upon increasing opportunities for these kinds of interactions. In contrast, following perceived risk events, interventions may be more effective if they focus on the deliberate, proactive, reflective decision making to seek, or to avoid, an HIV test (akin to 'opt-in' testing).

In this way, even a superficial exploration of the psychosocial context of HIV testing behaviours highlights the need for diverse approaches to testing interventions with regard to their target population (e.g. patient vs healthcare or community worker), their mechanism of action (e.g. capability approaches vs motivational approaches), anticipated positivity (e.g. high vs low), cost-effectiveness (e.g. tolerance for high vs low resource per test), the selection of testing technology according to the immediacy of receiving test results (e.g. rapid vs slower pace) and the location in which a person prefers testing to take place (e.g. if it is a routine, expected-to-be-negative test, home testing may be appropriate, but if positive results are expected a person may well want to test where face-to-face support and access to holistic care is readily available).

Technological contexts of testing behaviour

As described in the previous section, technological variation in HIV testing is growing. This brings with it increases in the choice of testing, as well as an increase in the scope and complexity of what the respective tests demand from both the testee and the test provider. Increasing choice of test is important because it relates to potential reductions in barriers to testing by increasing opportunities to test and enables the tailoring of different tests to specific psychosocial, cultural or service provision contexts. We believe facilitating choice in tailoring testing technology represents a novel and viable locus of intervention development for MSM.

Interventions that focus on choice and increasing opportunities to test must also address issues of capability because different tests demand different levels of skills, health literacy and, in some national contexts, material resources. With regard to self-managed tests, dry blood spot approaches demand a distinct behavioural repertoire (i.e. drawing and managing

Table 3. Psychological patterning of HIV testing and potential implications for services and intervention development

MSM, men who have sex with men; PrEP, pre-exposure prophylaxis; STI, sexually transmissible infection

	Psychological issues for testee	Service implication	Intervention opportunities
Testing in response to a 'one-off' perceived risk event	Assumes recognition of risk	Medium positivity potential	Suggests ongoing population-level interventions to educate MSM to recognise risk (e.g. after PrEP)
	Perceived risk of infection is high	Waiting period (due to window period and processing delays) and rapid results	The testing experience may represent a teachable moment: boost behavioural interventions to maintain safer behaviour or initiate PrEP if available
	Reflective decision-making process should be targeted within intervention mechanism of action	Arrange provision of support	Provides an entry into pathway for care and secondary prevention for positive tests
	Potential high levels of distress	Arrange provision of range of STI tests Arrange intensive partner notification Tolerance for higher-cost HIV tests	Consideration of approaches such as below
Testing in relation to ongoing high-risk behaviour	Perceived risk may be high	Challenge of identifying group of ongoing high-risk MSM or intravenous drug users	Personalised risk assessment may be useful for fostering testee and professional recognition of patterns of risk behaviour
	Other priorities may be more important than HIV risk	Ensure positive experience to encourage habit formation of service use	Intensive intervention may be needed to change the maintenance of problematic behaviour change
	Distal determinants of ongoing risk behaviour may be important (i.e. syndemics)	Establish relationship and continuation of care Arrange intensive partner notification Focus on patient choice given their potential diverse service needs	Reminders, triggers, behavioural prompts Testing bundles (wide range of STI and blood-borne viruses) may be appropriate Referral for PrEP
		Explore provision of testing bundles of STIs (convenience and self-management) High positivity risk (HIV), high STI risk	Candidates for intensive behavioural prevention that addresses the wider psychological and social determinants of risk
Testing in relation to higher risk due to group membership, or area of high HIV prevalence rather than risk behaviour <i>per se</i>	High HIV awareness but possibly low risk perception	Challenge of identifying group and encouraging testing without stigmatizing	Suggests identity-related interventions should be considered
	Maintenance of group membership	Ensure positive experience Establish relationship and continuation of care	Suggests interventions that focus on normative influence, social capital and social context should be considered Norm-based interventions that focus on prompts for repeat testing and peer support for testing should be considered
		Focus on patient choice Provision of testing bundles of STIs (convenience and self-management) Intensive partner notification	Focus on salutogenic issues and resilience
		Ensure positive experience and establish a sense of habit Normalise experience	
First ever test	Reflective decision making	Routine partner notification	School-based interventions should be considered to increase opportunities to test Mass media interventions should be considered to increase motivation and capability to test
	Associated with younger age or recent MSM conduct		Age-related interventions may capitalise on community norms Identity-related interventions may work, particularly for younger men and men recently coming out

(continued next page)

Table 3. (continued)

	Psychological issues for testee	Service implication	Intervention opportunities
Routine testing as sexual health screen	Low risk perception	Minimal attention to HIV <i>per se</i> Low positivity risk Routine partner notification	Interventions could focus on effective prompts for timely return to services Focus on salutogenic issues and resilience Explore self-managed testing interventions (e.g. postal delivery)

blood samples) compared with those associated with tests that use saliva. Equally, online ordering of test kits to be delivered to the home requires a set of different skills, behaviours and resources than those needed to travel to a testing site, book appointments and interact with a health professional. The interplay of psychosocial issues with the demand dimensions of the range of testing technologies remains underexplored, yet vital to harnessing future HIV testing interventions. It also highlights the importance of attending to health, social and economic inequalities and the structural determinants of testing. The heterogeneity of health care contexts and the varying accessibility of the range of testing approaches across national settings provide an interesting natural experimental design for monitoring choice-based testing interventions.

Temporal contexts

The historical nature of evidence concerning HIV testing interventions may limit its transferability to current contexts. However, we would argue it is also important to focus on the temporal aspects of an individual and what could be termed their testing career. The usefulness of population-level testing surveillance will be increasingly compromised if the temporal dimensions of individual testing patterns are not adequately addressed. The effectiveness of ART in reducing transmission among those living with HIV and those who take PrEP has stressed the importance of considering the temporal dimensions of HIV testing in the life context. Only test results that accurately reflect recent infection, or lack of infection, are useful to enable these biomedical preventative approaches. Older ways of thinking about testing that centred on diagnosis and access to treatment alone increasingly limit our thinking of testing interventions. This vestigial thinking that focuses on the dichotomy and durability of positive and negative test results limits our insights into the undiagnosed fraction of positive people, especially in those who have had a previous negative HIV test result.¹⁸ Measurement tools, data analysis and lay understandings often continue to focus on the dichotomy of 'ever versus never' tested rather than focusing on testing rates among those at ongoing risk. Equally, studies that conflate recency of testing with regularity of testing obscure the focus on regular, time-bound, repeat testing as a key behavioural goal necessary for fully using HIV testing for 2020. A deeper understanding of the frequency of testing, or inter-test intervals, is required¹⁹ to consolidate testing interventions for the future. Behavioural interventions must focus on specific aspects of the HIV testing domain (e.g. in the UK, targeting frequent self-sampling approaches among MSM at high risk, such as every 12 weeks, rather than annual testing through self-testing among the whole MSM population).

Population factors: heterogeneity of the MSM population and associated inequities

Social epidemiology tends to aggregate groups of people at the population level; for example, in the UK, 'MSM' versus 'Black African' as two primary populations at most risk of HIV. However, an appreciation of the heterogeneity of the MSM population (e.g. Table 4) in relation to HIV testing, across a range of dimensions, may lead to effective targeting of limited resources. As evidence of effectiveness of testing interventions develops, subpopulation specificity, or concerns about transferability in the MSM population, should be systematically highlighted. This 'granular' understanding of the MSM population would enable consideration of a range of simultaneous testing interventions, each addressing specific subpopulations; this enables consideration of developing testing interventions in relation to inequalities and the social determinants of testing. Such a pluralistic approach to understanding MSM and diverse testing interventions may ensure that testing interventions do not amplify health inequities in the MSM population as a whole. Instead, a range of acceptable and effective testing interventions could be available that can be tailored via user preference, capability and subpopulation specificity. Considerations of population segmentation highlight the stratification of effectiveness and cost-effectiveness. In as much as what works for one group of men (e.g. those that use the Internet and telephone apps regularly) may not work for others (MSM in rural communities with no 4G coverage) or, indeed, for the MSM population as a whole (e.g. social marketing or mass media approaches²⁰). Furthermore, subpopulation segmentation illuminates cost-effectiveness in relation to those who can only be reached by particularly expensive interventions.

Focus on barriers to testing

Barriers to testing represent a key way of considering population specificity. Among those who can acknowledge their vulnerability to HIV infection, grouping individuals according to their perceived barriers to testing can enable a useful and tailored repertoire of testing interventions. Targeting motivation-based testing interventions that focus on persuading those who are fearful of testing needs to be distinct from opportunity-based interventions, which target people who, for example, wish to seek testing but struggle to use current testing provision. Equally, where testing is readily available, not testing may relate to a failure to recognise risk exposure,¹⁶ thus highlighting the need for educational approaches delivered to the whole population. These different intervention targets demand interventions with different mechanisms of action and different modes of delivery.

Table 4. Population factors and their relationship to HIV testing
MSM, men who have sex with men; BME, black and minority ethnic

Population dimension	Implications for interventions
Barriers to testing	<p>Segment the population according to their barriers to testing to target different interventions</p> <p>Interventions may focus only on those who already have decided to test (e.g. focusing on choice and using user preference for technologies to facilitate regular testing)</p> <p>Interventions may focus on persuading those who may need to test to actually test through addressing the antecedents of testing decisions (e.g. focus on costs and benefits of testing)</p> <p>Interventions may focus on engaging those who are disengaged with HIV and are unaware of their risk (e.g. use mass media and focus on maximum reach)</p> <p>Self-complete personalised risk assessment may be a viable tool to enable people to realise the need to test or when to test (see Table 2), but this assumes a level of health literacy and prior engagement with the issue of HIV risk</p> <p>Intervene not only in relation to reducing barriers and increasing enablers to testing <i>per se</i>, but also to the particular use of the particular test (e.g. focus on reducing barriers to the use of self-managed blood spot-based testing)</p> <p>Address service provider barriers to testing, such as targeting key, difficult-to-reach but epidemiologically relevant subpopulations to increase opportunities for routine, wider sexual health screening and wider service uptake</p>
Lifespan perspectives	<p>Target and tailor interventions to establish testing within the young and testing patterns across the lifespan, thus promoting habit overall but also using different intervention approaches for different groups (e.g. differential use of social influence, such as descriptive, injunctive or personal norms according to life stage)</p> <p>Encourage and establish routine habitual HIV testing practices within health and community test providers new to post to foster habit formation use across their career</p>
Geographic considerations	<p>Distance from traditional health and community services may be prohibitive to testing (rural populations may benefit from different testing interventions to more urban populations)</p> <p>Accessing local services for small, closely knit communities may be problematic for perceptions of confidentiality (e.g. provide range of self-managed tests, such as self-sampling)</p> <p>Digital services may be mediated by geography, both compromised (lack of digital infrastructure) or enhanced (primary means of communication in dispersed populations)</p> <p>Postal self-sampling and testing options need to be able to be delivered conveniently and safely (e.g. packages should fit through standard mail slot)</p> <p>A variety of kit-collection options should exist (e.g. harnessing user preference and perceptions of control)</p>
Health literacy considerations	<p>Consider how choice of test or interventions to encourage testing behaviour may relate to the test kit's specific user demands: what are the user requirements in relation to issues such as understanding of the window period, meaning of reactive results</p> <p>Consider health literacy issues among the diverse provider populations who may offer the HIV test</p>
Digital literacy considerations	<p>Consider how accessing the test may presume digital literacy and economic resource with regard to the use of online service delivery</p>
Intersectionality, syndemics and social vulnerability	<p>Consider particular vulnerabilities of MSM who are BME, trans, use substances, have learning difficulties or who have mental health or poorer physical health</p> <p>Interventions designed to cover more syndemic or 'upstream' determinants of ill health may be needed to complement the proximal behavioural and psychological focus of HIV testing</p>

Lifespan perspectives

Key differences exist in relation to testing with regard to a person's life context. These are reflected the international literature, demonstrating strong positive correlations between age and testing.²¹ Regardless of perceived risk, testing for the first time may be associated with increased anxiety compared with repeat, habitual or routine testing later within sexual careers (e.g. as a necessary precursor to accessing PrEP). These lifespan perspectives may offer purchase to designing particular interventions for particular groups; for example, considering targeted interventions for young MSM that foster routine testing behaviours (including HIV) coupled with human papillomavirus vaccination or a focus on MSM in relationships.²²

Health and digital literacy

Many of the preceding sections have touched on issues relating to health literacy (e.g. the ability to recognise prior or potential risk through an understanding of the sometimes-complex factors

associated with HIV transmission). Addressing issues of health literacy is likely to be of fundamental importance to consolidating the opportunities available for HIV testing interventions.²³ Equally, the various testing technologies available present a range of user demands differentially requiring degrees of literacy, numeracy and manual dexterity. Moreover, because some of the self-managed tests lend themselves to digital distribution, it is important to acknowledge that although this approach removes barriers for some (e.g. those seeking to test in rural areas with little alternative testing provision), it may create barriers for others.²⁴ Such approaches necessitate a viable Internet connection and assume material and technical resources in order to be effective. In this way, even at a rural population level, although online self-testing interventions may prove a pragmatic and effective way of increasing testing, they are likely to so do only in a specific subpopulation (those with digital literacy and a particular level of material and technological resources). They may poorly serve those who may need HIV testing most.

Intersectionality, syndemics and social vulnerability

Finally, it is important to consider the specificity of subpopulations by traditional sociodemographic features and their intersections. The particular vulnerabilities of Black and minority ethnic MSM are well documented in some national contexts.^{25–28} Yet, how these vulnerabilities intersect with other important markers, such as age and poverty, are not well documented. Equally, the relationships between vulnerabilities and testing technology and the behavioural domain of HIV testing remain underexplored to date.

Discussion

If we are to maximise the individual and public health benefits presented by HIV testing interventions, we must think beyond the HIV test's diagnostic function and consider the technological, psychosocial and sociocultural contexts of HIV testing. The increasing diversification of the tests available demands systematic consideration of the right test for particular circumstances and particular subpopulations and recognises that, over time, the same person may well require different testing methods and settings. This multidimensional understanding of HIV testing will be important for patient preference, yet, scaled-up, it is equally important for considering the distribution of resources to support intervention design and, indeed, to make the most of available evidence detailing the effectiveness of testing intervention.

There is a danger that by not grasping the complexity of HIV testing and harnessing its emerging pluralities we will only reach the low-hanging fruit: designing, evaluating and implementing testing interventions that work for limited groups of people but do not affect the actual drivers of HIV transmission. There is a concern that if we only invest in one or two testing interventions and remove others, we may not affect HIV incidence and, indeed, we may be doing harm. For example, investing solely in interventions that work for urban gay men who use the Internet may systematically fail to provide testing interventions for men with low levels of health and digital literacy, amplifying health inequities. Embracing the complexity and plurality of testing interventions leads to the development of a programmatic and systemic approach to HIV testing interventions. Subsequent

research questions focus on how best to use available evidence from specific interventions with clear population parameters and how best to offer combinations of a range of interventions concurrently. These create ways of imagining new research questions (by testing technology, by the kind of testing decisions being targeted by interventions and by subpopulation parameters). They facilitate comparative research questions addressing the relative effectiveness of a variety of testing interventions and create ways of systematically thinking about ways of combining distinct yet complementary HIV testing interventions to address health inequalities and multiple barriers to testing.

In Table 5 we summarise the key dimensions of HIV testing we have identified within the paper; these are not exhaustive. We hope that these will prove useful in retrospectively considering the ways we describe HIV testing interventions and their effectiveness in order to build useful knowledge for future service provision through evidence synthesis. Moreover, we think these dimensions may also be useful for considering new ways of conceptualising future interventions and understanding the opportunities and limitations of current interventions. We believe that better interventions can be developed and described if we engage with this level of specificity (e.g. rather than describing 'Internet-delivered testing interventions' we can suggest 'using self-tests to target those mid-sexual career men who are seeking to test because of ongoing risk behaviour and who live in areas well served by Internet connections'). This is useful because it helps consolidate a nuanced evidence base. It also indicates who is likely to be excluded from engaging with the specified intervention and encourages us to think about who may require alternative interventions. For example, in relation to the example given, a complementary intervention may be needed that uses point-of-care testing in primary care and targets those who are in need of persuasive interventions to test in response to a 'one-off' perceived high-risk event or those who lack the material or psychological resources to use an HIV self-test kit. The dimensions, as listed, also facilitate an understanding of the differences in the economic, legislative and cultural context of nations, states or provinces that also constrain the possible parameters of these dimensions.

Table 5. Important dimensions to consider when describing and developing HIV testing interventions

Define the testing technologies used within an intervention	The specific context of HIV testing targeted in interventions	Dimensions to consider in relation to targeting populations for interventions
Self-testing	Testing in response to a 'one off' perceived high risk event	Barrier to testing (e.g., already made the decision to test vs need persuading to test)
Self-sampling	Testing in relation to on-going high risk behavior	Lifespan perspective (e.g., newly 'out', sexual debut)
Point of care	Testing in relation to higher risk due to group membership, or area of high HIV prevalence rather than risk behaviour per se	Geographical considerations (e.g., urban, rural, 3G, 4G)
Phlebotomy	First ever test	Health literacy considerations
Characteristics of result delivery	Routine testing as sexual health screen	Digital literacy considerations
Setting of test process	Testing in response to a 'one off' perceived risk event	Intersectionality, syndemics and social vulnerability
Window period	Testing in relation to on-going high risk behavior	
The type of sample used		

Conflicts of interest

None declared.

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