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Sexually transmitted infection prevention behaviours: health impact, prevalence, correlates, and interventions

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ABSTRACT

Sexually transmitted infections (STIs) remain a major public health threat, disproportionately affecting young people, and men who have sex with men. In this narrative review of the current state of behavioural science research on STI prevention, we consider the definition, health impacts, correlates and determinants, and interventions to promote STI prevention behaviour. Research on STI prevention behaviour has extended from a focus on abstinence, partner reduction and condom use, to also include novel preventive behaviours, notably treatment-as-prevention, pre-exposure prophylaxis (i.e., the preventive use of medicines by uninfected people), and vaccination for some STIs. Social-cognitive factors specified by, for instance the theory of planned behaviour, are critical proximal determinants of STI prevention behaviours, and related interventions can effectively promote STI prevention behaviours. Social-ecological perspectives highlight that individual-level determinants are embedded in more distal environmental influences, with social stigma especially affecting STI prevention behaviours and requiring effective intervention. Further to providing a major domain of application, STI prevention also poses critical challenges and opportunities for health psychology theory and research. We identify a need for health behaviour theory that addresses the processes linking multiple levels of influence on behaviour and provides practical guidance for multi-level behaviour change interventions adapted to specific contexts.

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Sexuality, according to the World Health Organization (WHO, 2006), is a central aspect of being human, and sexual satisfaction and healthy sexual functioning are considered integral and essential to quality of life (e.g., Yuen Loke, 2013). The term sexual health has come to refer to all aspects of sexuality related to health and wellbeing (Sandfort & Ehrhardt, 2004), including issues as diverse as sexual desire, sexual function, sexual

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networking, sexually explicit media use, non-consensual sex, and sexually transmitted infections (STIs), including infection with the human immune deficiency virus (HIV). This review is specifically concerned with STIs, which continue to pose a global public health threat and adversely affect sexual health.

Every day, more than one million STIs occur globally, and STIs are among the most common infectious diseases (Rowley et al., 2019). STIs, including HIV, can have serious long-term health impacts that affect an estimated 1.2 billion people globally (Vos et al., 2016). The brunt of the burden of STIs is borne by people in low- and middle-income countries (e.g., Unemo et al., 2017), and women are more affected than men (e.g., James et al., 2020). Also, younger people (< 25 years) are more affected than older people (e.g., Kreisel et al., 2021; Mohammed et al., 2018), and gay, bisexual, and other men who have sex with men (MSM) (e.g., Beyrer et al., 2016), and transgender people (e.g., MacCarthy et al., 2017) are disproportionately affected by STIs.

Health psychology can make important contributions to STI prevention, especially through theory-informed understanding and interventions to prevent behaviours that put people at risk. Here we review the current state of global STI prevention to highlight, guide and inspire health psychology contributions to this important and rapidly evolving health domain. We first define STI prevention, as situated in the broader sexual health domain, and consider the increasing range of STI prevention behaviours that are enabled by advances in biomedical research that has occurred since the early 2010s. We subsequently address the potential health impacts of STIs that can be mitigated by preventive behaviours. We then examine trends in the prevalence of established and emerging STI prevention behaviours in population groups most affected by STIs worldwide, notably young people and men who have sex with men (MSM). Next, we provide an overview of the evolving perspectives on the correlates and determinants of STI prevention behaviours, and especially highlight the rise to prominence of conceptual approaches that underscore the complex interplay of individual, social and structural factors. This is followed by an overview of theory-informed and evidence-based approaches to mitigate STI risk behaviours and their health impacts, signalling changes in approaches aligned with evolving conceptual understandings of STI risk and protection. We conclude the review with a consideration of the challenges and opportunities for health psychology to continue to make relevant contributions to STI prevention.

Defining STI prevention behaviour

STIs typically result from vaginal, anal, or oral penetration with the penis or contact between the mouth or tongue and the genitals or anus, but STIs can also be transmitted by skin contact or through penetration with fingers or objects, such as sex toys (Workowski et al., 2015). STIs were long seen as a moral problem and protecting population health from STIs was premised on a 'moral uplift' (Handsfield & Hoel, 1997, p. 271), that is, restricting sexual behaviour to monogamous (heterosexual) marriage. Abstinence and monogamy contribute to STI prevention by reducing the number of contacts who can be infected, and are especially promoted in STI prevention programs targeting young people that are rooted in religious or otherwise conservative worldviews (e.g., Breunig, 2017). Abstinence and restriction of sexual activity are, however,

aspirational or unacceptable for many young people (e.g., Visser, 2017), and pragmatic STI prevention draws on the so-called ABC-approach, promoting abstinence, being faithful, and condom use (Rukundo et al., 2016).

Male condoms have been used for centuries to prevent STIs (Amy & Thiery, 2015), and regained prominence as a prime HIV-prevention measure (e.g., Beksinska et al., 2020). When used consistently and correctly, male condoms are a highly effective method to prevent STIs (WHO, 2019; Workowski et al., 2015), and may reduce the risk of infection by 80% (Weller & Davis, 2002). The use of female condoms has gained interest and momentum, especially in Sub-Saharan Africa, as a means of female controlled prevention (e.g., Vijayakumar et al., 2006). While female condoms are effective, their acceptability among women and their sex partners remains a challenge (Peters et al., 2014). In addition to condom use, there is also evidence for the partial effectiveness of behavioural strategies to reduce the risk of HIV when engaging in condomless intercourse (e.g., Jin et al., 2009), notably serosorting (having sex only with other HIV negative men) and seropositioning (only taking the insertive role during intercourse that holds less risk of HIV; cf. Jin et al., 2010). These strategies can also reduce the risk of other STIs, notably chlamydia, gonorrhoea, and syphilis, during condomless intercourse in MSM (Jin et al., 2012).

Effective treatment also is a critical pillar of STI control, as it mitigates adverse health impacts and reduces the risk of onward transmission (van Bergen et al., 2021). Antibiotic treatments can cure some STIs, such as chlamydia, gonorrhoea, syphilis and trichomoniasis, and there are established forms of (secondary) prevention (UNAIDS, 1998), including through partner notification, testing and treatment (e.g., Workowski et al., 2015). STI treatment is typically initiated upon diagnosis, but antibiotics may also be provided presumptively, including to sexual partners, when the risk of infection is high (e.g., Workowski et al., 2015).

Successful HIV treatment all but eliminates the risk of transmission to uninfected sexual partners (Cohen et al., 2011), which has enabled a range of biomedical HIV prevention strategies. In addition to the early initiation of treatment-as-prevention (e.g., Flash et al., 2012), antiretroviral drugs (i.e., antiretrovirals, ARVs) used for HIV treatment can also be taken by non-infected people to reduce the likelihood of acquiring HIV after potential exposure (i.e., post-exposure prophylaxis; PEP), which can be occupational (e.g., accidental needle stick) as well as non-occupational (e.g., condom slippage or breakage) (e.g., Krakower et al., 2015). Furthermore, using ARVs before potential exposure (i.e., pre-exposure prophylaxis; PrEP) may be as effective in preventing infection as condom use, if not more, and can, reduce the risk of HIV infection in HIV-negative MSM by 86%, if well adhered to (e.g., Buchbinder, 2018). Testing for HIV, and other STIs, is a critical gateway to treatment-based prevention (cf., Freeman et al., 2018). A range of options is now recommended to facilitate timely and regular HIV testing and ensure accurate diagnosis, including rapid point-of-care tests for use in clinical and non-clinical settings and self-testing (e.g., WHO , 2020a).

Vaccination is a key component of infectious disease control, which can contribute to the eradication of transmission in humans (e.g., McLean, 1998). With respect to STIs, effective vaccines are only available for Hepatitis B virus (HBV) and Human Papilloma Virus (HPV) infections, although vaccines for other STIs are being explored (McIntosh, 2020). HBV vaccination became available in the early 1980s and was first

recommended for people at increased risk for HBV, including through sexual contact, such as MSM (Haber & Schillie, 2021). To achieve universal coverage, HBV vaccination is included in infant immunization programs in over 95% of countries (Gottlieb & Johnston, 2017). Since 2006, HPV vaccination is provided to girls aged 11-12 years through national immunization programs, and as of 2011, HPV vaccination is also becoming available for boys (Markowitz et al., 2018). However, implementation and uptake of HPV vaccination remain challenging globally, in lower as well as higher income countries (Dilley et al., 2020).

Health impact of STI risk behaviours

Over 30 known pathogens (i.e., bacteria, viruses, or parasites) are exclusively or predominantly transmitted through sexual contact or are also transmissible during sexual contact (Torrone et al., 2021). Much of the burden of disease related to STIs is attributed to the eight most common STIs: gonorrhoea, syphilis, chlamydia, trichomoniasis, hepatitis B virus (HBV), human papilloma virus (HPV), herpes simplex virus (HSV) and HIV (Torrone et al., 2021). Table 1 provides an overview of these major STIs, their common symptoms, possible complications and treatment.

The WHO estimates that, in 2016 alone, 376.4 million infections with gonorrhoea, syphilis, chlamydia and trichomoniasis occurred globally in women and men, aged 15–49 years (Rowley et al., 2019). These STIs, caused by bacteria (i.e., gonorrhoea, syphilis and chlamydia) or a parasite (trichomoniasis) are effectively curable by antibiotics, but it is of concern that gonorrhoea has become resistant to antibiotics and treatment now requires combination regimens, with a noted need for novel treatments (Unemo et al., 2017). Gonorrhoea, syphilis, chlamydia and trichomoniasis often have no symptoms (WHO, 2019). If untreated, these STIs can, however, have serious health complications, especially for women. Also, gonorrhoea and chlamydia can be transmitted from mother to child, and syphilis can cause premature delivery, stillbirth, neonatal death, and severe infant disability (e.g., Rowley et al., 2019; Unemo et al., 2017).

The major STIs caused by viruses (i.e., HBV, HPV, HSV and HIV) are not curable and can have serious, chronic health impacts. HBV is an infection of the liver that can have acute symptoms, including yellowing of the skin and eyes (i.e., jaundice), and may develop into chronic, life-threatening liver disease, resulting in liver cirrhosis and liver cancer, that causes nearly 900,000 deaths annually (WHO, 2017, 2020a). An estimated 100 million people are newly infected with HBV each year (Vos et al., 2016), and nearly 300 million people worldwide are affected by chronic HBV (WHO, 2017). Sexual transmission of HBV especially affects MSM and heterosexual people with multiple sex partners (e.g., WHO, 2020b).

HPV infection is lifelong, and while most of the more than 200 variants do not cause any symptoms and may resolve spontaneously, some variants can cause persistent genital warts and others can cause cancer (Serrano et al., 2018). HPV variants are responsible for nearly all cervical cancers and are related to other cancers of the anogenital region (i.e., vulva, vagina, anus, and penis), as well as to cancers of the tongue, tonsils and other parts of the mouth and throat (Serrano et al., 2018). An estimated 11.7% of women globally were infected with HPV in 2017 (Serrano et al., 2018). Infection rates are highest in women under 25 and numbers of infections in

Table 1. Main sexually transmitted infections (causative agents), common symptoms, possible complications and available treatment.

Type of infection	Common symptoms	Possible complications	Treatment
Chlamydia (Chlamydia trachomatis, bacteria)	Often no symptoms; possibly genital discharge and/or burning sensation when peeing	Pelvic Inflammatory Disease in women (risk of long-term abdominal pain, ectopic pregnancy, and infertility); in men complications are rare	Antibiotics
Gonorrhoea (Neisseria gonorrhoeae, bacteria)	Often no symptoms; possibly genital discharge and/or burning/painful sensation when peeing	Pelvic Inflammatory Disease in women (risk of long-term abdominal pain, ectopic pregnancy, and infertility); pain of the testicular tubes in men with rare risk of infertility	Antibiotics
Syphilis (Treponema pallidum, bacteria)	First painless single or multiple sores at point of entry in the body; later skin rashes and/or sores in mouth, vagina, or anus	Damage to organ systems, including the heart and blood vessels, the brain and nervous system, the eyes and the ears	Antibiotics
Trich(omoniasis) (Trichomonas vaginalis, protozoan parasite)	Mostly no symptoms; possibly discharge from penis or vagina, genital itch and/or discomfort or burning sensation or when peeing	Sex can feel unpleasant; increased risk of other STI, including HIV, due to genital inflammation	Antibiotics
Hepatitis B (Hepatitis B Virus)	Often no symptoms; possibly fever, joint pain, fatigue, loss of appetite, nausea/vomiting, abdominal pain, dark urine, clay-colored stool, and/or jaundice	Chronic infection poses increased risk of premature death due to cirrhosis or cancer of the liver	No treatment for the virus but treatment available for related health conditions; preventive vaccine available
Human Papilloma Virus	Mostly no symptoms	Genital warts; cervical cancer; cancer of the vulva, vagina, penis, or anus; oropharyngeal cancer	No treatment for the virus but treatment available for related health conditions; preventive vaccine available
Genital herpes (Herpes Simplex Virus Type 1 or Type 2)	Mostly no or very mild symptoms; possibly one or more blisters on or around the genitals, rectum or mouth (i.e., "outbreak"); flu-like symptoms during first outbreak	Pregnancy complications; infection of foetus or new-born baby	No treatment for the virus but treatments to prevent or shorten outbreaks
HIV (Human Immunodeficiency Virus)	Some have flu-like symptoms 2 to 4 weeks after infection (i.e., "acute HIV infection")	Acquired Immune Deficiency Syndrome (AIDS): increasing number of severe illnesses (i.e., opportunistic infections resulting from a badly damaged immune system)	Combination antiretroviral therapy to control the virus

Source: https://www.cdc.gov/.

men are possibly higher than in women, albeit possibly less persistent (Serrano et al., 2018).

HSV infection is also lifelong and characterised by periodic reactivation of sores at affected sites, with HSV type 1 mostly affecting the mouth and lips (i.e., cold sores) and HSV type 2 affecting the genital region, albeit that genital HSV type 1 is becoming more common (James et al., 2020). While there is no cure or vaccine, antiviral medication can ease HSV-related symptoms (WHO, 2020c). HSV can be transmitted during or after childbirth, with a high risk of neonatal death and disability (James et al., 2020). HSV type 2 infection also increases the likelihood of acquiring HIV (Looker et al., 2017). In 2016, over 3.7 billion people had HSV type 1, and nearly 500 million people had HSV type 2 (James et al., 2020).

The global HIV epidemic is one of the biggest infectious disease threats to population health in known history. HIV can cause AIDS (Acquired Immune Deficiency Syndrome), a life-threatening impairment of the immune system. Since the epidemic emerged in the early 1980s, over 72 million people have become infected with HIV, of whom 37.6 million were alive by the end of 2020 and nearly 35 million had died (WHO, 2020d). Nearly three-quarters of people with HIV globally have access to life-saving treatment (WHO, 2020d), which does not offer a cure but has transformed HIV into a chronic, manageable condition. HIV-related deaths decreased from a peak of 1.95 million in 2006 (GBD 2017 HIV Collaborators, 2019) to 690,000 in 2020 (WHO, 2020d). More than half (20.7 million) of people with HIV live in Eastern and Southern Africa, where HIV is mostly sexually transmitted in the general population and where young women aged 15-24 remain at highest risk (UNAIDS, 2021). The risk of acquiring HIV through sexual contact is highest among young people and MSM, as well as other key populations, including transgender people and sex workers and their clients, and the sexual partners of key populations (UNAIDS, 2021).

STIs, especially HIV, can also adversely impact the mental health of people affected. Depression rates are elevated in people with HIV, including adolescents (Ayano et al., 2021), HIV infection is associated with anxiety symptoms and disorders (Brandt et al., 2017), and people with HIV are at increased risk of post-traumatic stress disorder (Tang et al., 2020). The mental health of people with an STI is particularly affected by ongoing social stigma (e.g., Lee & Cody, 2020). Social stigma refers to the devaluing of people and groups because of characteristics related to their body (e.g., having an STI), behaviour (e.g., condomless sex), or group membership (e.g., identifying as gay) (e.g., Link & Phelan, 2001). HIV-stigma, which can be experienced, perceived, witnessed, anticipated, or internalized (Nyblade et al., 2021), is associated with higher levels of depression and lower levels of social support and, to a lesser extent, with more anxiety and distress, and lower quality of life (Rueda et al., 2016). Negative effects of social stigma are also noted for HBV (Tu et al., 2020).

Prevalence of STI prevention behaviours

The initiation of sexual behaviour is normative among adolescents (e.g., Epstein et al., 2018). In the USA, for example, about a quarter of young people have had sex by the age of 16, which increases to about half by the age of 18, and three quarters are sexually initiated by the age of 20 (Finer & Philbin, 2013). Early sexual debut, that

is, before the age of 16 (Wellings et al., 2001), is associated with increased sexual risk behaviours (i.e., more sexual partners, not using condoms) and STIs (see Ethier et al., 2018). Age of sexual debut may be increasing, as reflected in a decrease between 2005-2015 in the proportion of US high school students who ever had sex (Ethier et al., 2018). A study in Scotland found that while the likelihood that adolescents had sex decreased between 2002-2014, condom use at last sex had also become less likely (Neville et al., 2017). Research in the US also found that condom use decreased among high-school students, with just over half (55%) of sexually active students reporting condom use at last sex in a 2019 survey (Szucs et al., 2020). A survey in Canada found that 60% of sexually active 15–24-year-olds had used a condom at last sex (Rotermann & McKay, 2020).

Rates of testing for STIs other than HIV are low among adolescents. A 2013 national survey of young people (15-25 years) in the US, for instance, found that 17% of young women and 6% of young men had tested for STIs in the past 12 months (Cuffe et al., 2016). Because STIs are often asymptomatic, periodic screening of young people is recommended, but its uptake is low. A study in the Netherlands found that only 12% of invited young people participated in a chlamydia screening program (Van den Broek et al., 2012), and in Australia only 24% of young people were tested in clinics offering chlamydia testing to all 16–19-year-olds (Hocking et al., 2018). HIV testing rates also are low among adolescents, with a study from the US reporting that 22% of sexually active high school students and 33% of young adults aged 18-24 had ever tested for HIV in the period 2005-2013, with no significant changes found over time (Van Handel et al., 2016). However, in South Africa, a country severely affected by HIV, rates of having ever tested for HIV among 15–24-year-olds to increased from 19% in 2005 to 59% in 2017 (Jooste et al., 2020).

It is estimated that, by 2017, HBV vaccination coverage of infants at 24 months of age was 84% globally (e.g., Stasi et al., 2020), and over 90% in the US (e.g., Hill et al., 2019).). HBV vaccination coverage is, however, uneven, with lower rates in Latin America, Africa, and the Eastern Mediterranean than in the Western Pacific, South-East Asia and Europe (cf. Peck et al., 2019). Also, older generations are less protected through more recently implemented universal vaccination than younger generations (e.g., Le et al., 2020). Regarding HPV vaccination, 2016 estimates from Australia, where a national HPV vaccination program was first implemented, show that coverage by age 15 was 79% among females and 73% among males (cf. Hall et al., 2019). HPV vaccination uptake has been found to be slower in the US, where by 2017 HPV vaccination was up to date in less than 50% of adolescents aged 13-17 years (49%; females: 53%, males: 44%) (Walker et al., 2018).

Condom use has long been the most prominent STI prevention behaviour among MSM, but consistent condom use is challenging. Already in the early 1990s MSM were noted to use alternative behavioural strategies to reduce the risk of HIV during condomless sex, based on HIV status information, notably serosorting and seropositioning (e.g., Khosropour et al., 2021). Since the mid-1990s, with the advent of effective HIV treatment, rates of condom use have steadily declined among MSM globally (e.g., Chow et al., 2019). This decline in condom use among MSM accelerated in the early/mid 2010s, when HIV prevention changed markedly through the promotion of HIV treatment as prevention and PrEP (e.g., Chen et al., 2019).

Research among MSM attending a sexual health clinic in Seattle has shown that, between 2002 and 2018, consistent condom use in the past 12 months declined from 35% to 11% among men without HIV and from 20% to 5% of men with HIV (Khosropour et al., 2021). In that same period, uptake of HIV-treatment increased to 94% of men with HIV and by 2018 PrEP was used by 50% of men without HIV (Khosropour et al., 2021). Population estimates for MSM in San Francisco, a city at the forefront of the paradigm shift in HIV prevention, suggest that consistent condom use decreased from 19% of MSM in 2014 to 9% in 2018, while PrEP use increased from 10% of MSM to 45% (Chen et al., 2019). Periodic surveys in Sydney and Melbourne found that consistent condom with casual partners in the preceding six months decreased from 46% of MSM in 2013 to 31% in 2017, while the proportion of MSM without HIV who had condomless anal sex with causal partners and used PrEP increased from 1% in 2013 to 16% in 2017 (Holt et al., 2018).

Regular STI testing has become increasingly critical to successful STI control among MSM (Adam et al., 2014), but remains insufficient. Globally, only about half of MSM with HIV are aware of their HIV status (cf. Campbell et al., 2018). HIV status awareness in MSM has nevertheless increased in MSM across the African continent, with 67% estimated to have ever tested for HIV (Stannah et al., 2019). HIV testing rates have also increased among MSM in the US, where a 2018 online survey found that 72% of MSM had ever tested for HIV and 53% had tested in the past 12 months (Wiatrek et al., 2021). STI testing rates in MSM were found to be lower, in particular among MSM without HIV of whom 41% reported STI testing in the past 12 months, compared to 73% of MSM with HIV (Wiatrek et al., 2021). A study among MSM in Australia found that only 29% had a HIV testing routine (i.e., tested on a regular basis), and 28% had an STI testing routine (Adam et al., 2014). Furthermore, while younger generations of MSM benefit from universal HBV vaccination, coverage was found to be only 53% among adult MSM in the US (Srivastav et al., 2019), and 57% among MSM in European countries (Brandl et al., 2020). A 2018 survey of MSM in the Netherlands found that 60% had been fully vaccinated against HBV (Den Daas et al., 2020). Universal HPV vaccination for boys has only recently been initiated in some countries, and also remains limited in countries where it is available to adolescent and young adult MSM, such as France (Petit & Epaulard, 2020).

Correlates and determinants of STI prevention behaviours

The emergence of the HIV pandemic, in the early 1980s, coincided with the rise to prominence of social cognition models of behaviour, which at the outset had a strong influence on research into the factors related to of STI prevention behaviour, in particular condom use. The Theory of Reasoned Action (TRA), and its extension, the Theory of Planned Behaviour (TPB), have been widely used to understand condom use to prevent STIs. A meta-analysis of TRA/TPB research of correlates of condom use, undertaken mostly in the second decade of the HV epidemic (1990-2000), included 95 datasets with a total of more than 22,000 participants (Albarracín et al., 2001). Findings were in line with theoretical predictions, and associations between behaviour and intentions, and between intentions and attitudes, subjective norms, and perceived behavioural control (PBC) were significant; PBC was however not significantly

associated with behaviour. Furthermore, associations between intention and behaviour were lower when including past behaviour in analyses, and in higher risk samples than in lower risk samples. A more recent meta-analysis of research testing TPB constructs as correlates of condom use among MSM found that attitudes, subjective norms and PBC explained only 24% of the variance in intention, and intention and PBC explained merely 12% of the variance in behaviour, with no significant additional effect of PBC on behaviour observed (Andrew et al., 2016). A systematic review and meta-analysis of research into social-cognitive factors related to condom use in sub-Saharan African youth has taken a more integrative conceptual stance guided by TPB, the health belief model (HBM) and other theories (Protogerou et al., 2018). This review found further evidence of associations between condom use intentions and attitudes, norms, and perceived control. Furthermore, condom use was found to be associated with intentions, perceived control, and perceived barriers. Past condom use was also found to associated with condom use intentions and behaviour.

A systematic review of research into psychological variables associated with HIV testing found that a wide range of social-cognitive and affective variables was assessed across studies (Evangeli et al., 2016). Knowledge and perceived risk of HIV were most frequently assessed and meta-analyses found small positive associations with HIV testing for both variables. Tallying findings for other, less studied variables, Evangeli et al. (2016) conclude that most studies provided support for positive associations between HIV testing and knowledge of HIV, knowledge of HIV testing sites, perceived risk of HIV, perceived benefits of HIV testing, perceived behavioural control or self-efficacy regarding HIV testing, and knowing someone with HIV. Majorities of studies were also noted to provide support for negative associations with fear of HIV testing and prejudiced attitudes towards people living with HIV. There is also evidence that social-cognitive factors are associated with STI testing. A recent systematic review of qualitative, quantitative and mixed methods research applied the Capability, Opportunity, and Motivation Model of Behavior (COM-B model) to identified barriers and facilitators of testing for Chlamydia, at the patient level as well as the provider and service levels (McDonagh et al., 2018). At the patient level, which is most pertinent for the current review, observed barriers and facilitators were related to psychological capability (lack of patient (and public) education, knowledge, and awareness; forgetfulness), reflective motivation (beliefs regarding perceived risk; beliefs that testing is responsible, mature, and healthy), automatic motivation (embarrassment; fear; worries about asymptomatic infection), social opportunity (stigma), and physical opportunity (mode of testing; primary care providers offering testing).

Vet et al. (2017) undertook a systematic review of research into factors related to HBV vaccination among MSM in low prevalence, high-income countries, and found evidence for the important role of social-cognitive factors included in TPB and HBM. Converging evidence was found in support of associations between HBV vaccination and knowledge, perceived vulnerability and perceived severity regarding HBV infection, and perceived barriers to HBV vaccination. A systematic review of reviews undertaken Rodriguez et al. (2020) to develop a framework of factors related to HPV vaccination amongst adolescents in the US, underscored the role of social-cognitive factors at the level of parents. Across synthesized reviews, HPV vaccination of adolescents was found to be associated with parents' knowledge of HPV and HPV vaccination, beliefs

regarding their child's susceptibility to HPV, perceived severity of HPV infection, perceived benefits of vaccination, perceived vaccine efficacy, perceived vaccine safety, and vaccination intention (Rodriguez et al., 2020).

Research on STI prevention behaviours has also contributed to advancing social cognitive theories of behaviour, notably the development of the prominent Information-Motivation-Behavioural-Skills (IMB) model of HIV risk and preventive behaviour (Fisher & Fisher, 1992). The IMB model posits that HIV prevention information, motivation, and behavioural skills are the fundamental determinants of HIV risk or preventive behaviour, and that the influence of information and motivation on behaviour is generally mediated by behavioural skills. A narrative review documented support for the model's assumptions in 26 studies of condomless sexual behaviour in diverse populations, including MSM and young people, and cultural and geographic settings including the US, sub-Saharan Africa and India (Fisher et al., 2014). A further narrative review organized research findings on correlates of HPV vaccine uptake according the IMB model, and found empirical support among parents, young people and health care providers (Fisher, 2012).

Social cognition models, such as TPB and IMB, specify various types of beliefs that are thought to guide mostly reasoned decisions to engage in a specific behaviour (e.g., Fishbein, 2000). Theories of self-regulation extend this perspective by underscoring that behaviour is the result of a complex interplay between multiple, potentially conflicting goals that involves reasoned as well as automatic processes (e.g., Kotabe & Hofmann, 2015). Research explicitly applying a self-regulation perspective to STI risk and prevention behaviours is limited, but an overview of research assessing the role of factors related to self-regulation found that various dispositional and situational factors may affect STI risk and prevention behaviours (De Wit et al., 2017). The compiled evidence shows that momentary or chronic higher levels of sexual desire, which may conflict with risk reduction goals, can adversely affect protective sexual behaviours, as can impulsivity, substance use and other factors that undermine capacity for self-control. It was also found that the interpersonal sexual context, especially steady relationships, reduces motivation for STI protection, as do changes to the HIV prevention context, as exemplified by reduced threat because of the effective treatment of HIV.

Psychological theories specify critical proximal determinants of STI prevention behaviour, but these individual-level theoretical approaches have come to be seen as incomplete (e.g., Coates et al., 2008). Importantly, it has been noted that STI risk only arises in sexual interactions with others, and STI prevention behaviour is enacted in social environments that can be more or less supportive (Coates et al., 2008). It is hence the interplay between individuals' agency, reflecting their motivation and skills, and the social conditions and structural arrangements in which they are embedded that is thought to shape people's STI-related behaviours (e.g., Auerbach et al., 2011). Recognition of the importance of understanding individuals in their environment has given rise to social-ecological models of behaviour that distinguish influences at multiple, nested levels. The influential social-ecological model for health promotion, proposed by McLeroy et al. (1988), distinguishes factors affecting behaviour at five levels of influence: intrapersonal factors (e.g., knowledge, attitudes, skills), interpersonal processes and primary groups (social networks, support systems), institutional factors

(organizational characteristics, operating rules and regulations), community factors (relationships and networks among organizations and institutions), and public policy (laws and policies at local, state, and (inter)national levels). A review of multilevel assessments of factors influencing HIV-related behaviour summarized the existing evidence in an extensive list of variables organized according to their position on the individual-structural spectrum of influence (Kaufman et al., 2014). Termed a 'menu of behaviour change factors' (Kaufman et al., 2014, p. S251), the review suggests a taxonomy of influences on HIV-related behaviours at the individual (e.g., risk perception), interpersonal/network (e.g., relationship power), community (e.g., cultural norms), institutional/health system (e.g., provision of appropriate services) and structural (e.g., poverty) levels.

Based in sociological theory, the analysis of environmental influences on STI-related behaviours has come to supersede the previously dominant focus on individual social cognitions and has especially focused on understanding the social drivers of vulnerability that affect the ability of people to protect themselves and others (e.g., Auerbach et al., 2011). These social determinants encompass the norms and values that guide behaviour, as well as the networks and institutions in which these factors manifest in patterned ways (e.g., families, religious groups, schools, workplaces, legislative and policy systems) (Auerbach et al., 2011). In line with a social-ecological approach, a population survey of male and female adolescents in Canada found that family-related factors (i.e., disrupted family structure, low family support) were most strongly related to early sexual initiation (Gazendam et al., 2020). Also, in Scotland, economic inequalities were found to persist in early sexual initiation and condom use among adolescents (Neville et al., 2017). Health systems factors, notably confidentiality concerns, were found to be important deterrents of STI testing among adolescents in the US (Cuffe et al., 2016), as were feelings of embarrassment and the potential for stigma related to STI testing among peers (Fleming et al., 2020). The adverse impacts of social stigma have long been noted and are extensively researched with respect to HIV-related protective behaviours. A scoping review of reviews synthesized ample evidence that HIV-related stigma, which may be experienced, perceived, anticipated, or internalized, is a major barrier to HIV testing, linkage and retention to HIV care, and uptake and adherence to HIV treatment (Nyblade et al., 2021). The impact of HIV-related stigma is compounded among key populations who experience intersectional stigma, related to being part of a marginalized social group or engaging in non-normative sexual behaviours (Nyblade et al., 2021).

Interventions to promote STI prevention behaviours

Interventions to reduce sexual behaviours that put people at risk of STIs (e.g., early initiation of sex) and promote preventive behaviours (e.g., condom use) have long been the backbone of STI control, predominantly for HIV prevention. However, by the late 2000s/early 2010s the global HIV pandemic was continuing largely unabated, which was conducive to claims that 30 years of behavioural prevention was failing (cf. Kippax & Stephenson, 2012). As a case in point, biomedical scientists pointed to the absence of evidence from randomized controlled trials that behavioural interventions promoting protective sexual practices could reduce new HIV infections and highlighted that such evidence was available in support of novel biomedical

interventions (e.g., Padian et al., 2010), which include the now much promoted treatment-as-prevention and PrEP. Biomedical prevention, however, also relies on people's behaviours (e.g., Kippax & Stephenson, 2012). Interventions are hence required to promote an increasing range of STI prevention behaviours, including getting tested regularly, and initiating and adhering to HIV-treatment or PrEP. Avenues to strengthen HIV prevention centre around the notion of combination prevention (Coates et al., 2008), that is, drawing on a mix of communication channels and making use of the full range of prevention approaches, including behavioural, biomedical, and structural interventions.

Numerous studies have tested a diversity of behavioural interventions to promote condom use and reduce sexual risk behaviours. HIV prevention interventions for MSM target individuals (mostly counselling or motivational interviewing by a counsellor, educator, other professional or peer), small groups (typically multisession discussions led by a counsellor, facilitator, or peer) and communities (e.g., deploying popular opinion leaders) (see Herbst et al., 2007). Typical interventions for young people are sexuality education programs delivered in-school, after school in community settings, or in health clinics (see Goesling et al., 2014). The conclusion from a large body of evidence is that behavioural interventions can effectively promote condom use and reduce condomless sex, numbers of sex partners and rates of STIs in most affected population groups, including young people and MSM (e.g., Noar, 2008; Scott-Sheldon et al., 2011). On average, behavioural interventions resulted in a 32%-34% increase in the odds of condom use or reduction in the odds of condomless sex and STIs; effects on numbers of partners were smaller, with an average 15% reduction observed (Noar, 2008). There is also meta-analytic evidence that behavioural interventions can significantly reduce numbers of HIV infections (Scott-Sheldon et al., 2011), assuaging earlier concerns of a lack of robust evidence (e.g., Padian et al., 2010).

A meta-analysis provided evidence that behavioural HIV prevention specifically targeting adolescents can reduce rates of STIs and numbers of sexual partners, increase condom use, and reduce or delay penetrative sex (Johnson et al., 2011). Support has also been compiled in a review of systematic reviews that school-based sexual-health and relationship education programs can reduce adolescent sexual risk behaviours, although abstinence-only programs are ineffective (Denford et al., 2017). Furthermore, a systematic review of studies mostly with adolescents and young adults found that individual behavioural counselling in primary care can increase condom use and reduce sexual risk and rates of STIs (Henderson et al., 2020). There is also evidence from a meta-analysis that digital communication technology-based interventions (e.g., computer programs, texting, websites, social media, and combinations thereof) can increase condom use and abstinence in young people (Widman et al., 2018).

For MSM, a review of systematic reviews found strong and consistent evidence that group- and community-level behavioural interventions can promote condom use and reduce condomless sex, with inconsistent evidence found for individual-level interventions (Lorimer et al., 2013). A more recent systematic review, however, found that individual-level interventions, in particular counselling after a previous HIV-negative test, can also reduce sexual risk behaviours among MSM (Flowers et al., 2017). Behavioural interventions delivered via eHealth approaches (i.e., internet-based tools

and interactive computer programs) have also been found to be effective in increasing condom use and decreasing numbers of sex partners among MSM, as well as increasing rates of HIV testing (Xin et al., 2020).

Evidence syntheses have also contributed important insights into the characteristics of effective interventions to influence STI-related behaviours and outcomes, including aspects of intervention content, which is mostly derived from social-cognitive behavioural theories. Overall, Albaraccin et al. (2005) found that interventions limited to communication to largely passive audiences are less effective than interventions that also include active components, such as counselling or HIV testing. Furthermore, in support of social cognitive theories, the authors found that most effective interventions included educational information, attitudinal arguments, behavioural skills arguments, and behavioural skills training. For interventions targeting adolescents, effective characteristics include recipient characteristics (e.g., age, vulnerability to STIs/HIV); design features, notably the use of (social-cognitive) theory, formative research and a higher dose of intervention content; attention to aspects of environments in which behavioural interventions are implemented (e.g., supportive school environments); and use of behaviour change techniques, notably addressing motivational enhancement, skills building (e.g., condom use, communication and negotiation skills) and social influence (Johnson et al., 2014; Protogerou, & Johnson, 2014). Theory-based interventions and interventions including skills building were also consistently effective among MSM (Lorimer et al., 2013).

Testing and treatment have long been central to the control of bacterial STIs (e.g., Van Bergen et al., 2021), and more recently have become to play a critical role in the control of HIV (e.g., Cohen et al., 2011). While proposed as an alternative to traditional behavioural prevention promoting sexual risk reduction, the success of biomedical approaches remains contingent on people's behaviours (e.g., Kippax & Stephenson, 2012). Various approaches have hence been developed and evaluated to promote uptake and strengthen use of biomedical prevention. This has resulted in an extensive body of research testing interventions to increase rates of testing for bacterial STIs and HIV, in particular among MSM. Interventions to increase rates of HIV testing among MSM have been classified into two broad categories (Campbell et al., 2018), which are also relevant for STI testing and for testing in young people and other population groups: test delivery (i.e., the settings and modalities for testing) and test promotion (i.e., strategies to reach and recruit people for testing). Test delivery interventions to increase uptake include modifications to clinic-based testing (e.g., opt-out testing, MSM-friendly services), community-based testing (e.g., at pharmacies, mobile vans or community venues), and self-testing, while test promotion interventions encompass partner counselling and referral services, social networking strategies (i.e., reaching MSM through other community members), social marketing campaigns, and digital technology-based communication (e.g., ads on popular websites, intervention-specific websites, new apps) (Campbell et al., 2018).

A review and evidence synthesis found that all testing delivery interventions (i.e., modifications to clinic-based testing, community-based testing, and HIV self-testing), and one test promotion approach (i.e., social network strategies) can effectively reach subsets of MSM, although evidence was limited and success is likely context-specific (Campbell et al., 2018). A systemic review of interventions for adolescents and young

adults also found that digital technology-based communication, alternative venue/self-testing interventions and peer/community-focused interventions can increase HIV-testing, as can educational interventions and the use of incentives (Zanoni et al., 2018). Also, school-based testing for chlamydia and gonorrhoea was found to be feasible and cost-effective (Lewis et al., 2016).

Digital communication technology (eHealth) has become much used to promote testing uptake as well as treatment adherence, and a systemic review found that text messaging, mobile phone apps or other internet-based interventions (e.g., websites, online and social media campaigns, streamed videos, interactive computer programs) and combination interventions could enhance treatment adherence, with some interventions also increasing clinic attendance and partner notification and self-care (Daher et al., 2017). mHealth, the use of mobile phone functionalities, have become particularly important tools to promote STI prevention, with positive effects on HIV testing uptake found for text messaging and smartphone apps (Berendes et al., 2021). Research among MSM has also found positive effects of social media interventions (i.e., disseminating information, providing HIV-testing services, building supportive online communities, and developing information materials) on HIV testing uptake (Cao et al., 2017). Evidence remains to be synthesized regarding the active ingredients of digital communication technology-based interventions, especially with respect to the use of theory, alignment with factors that shape behaviours and use of behaviour change techniques.

Interventions have also been developed and tested to promote vaccination against STIs, especially with respect to HPV vaccination in young people. A systematic literature review found three types of intervention strategies promoting HPV vaccination that targeted adolescents, parents and/or healthcare providers: reminders, education, information and communication activities, and multicomponent strategies (Acampora et al., 2020). While evidence was found in support of the efficacy of all types of strategies for all target groups, findings were heterogeneous. A systematic review and meta-analysis of interventions to promote HPV vaccination found that the use of the IMB model was associated with positive effects on attitudes, intentions or behaviour; no positive effects were found for the use of the HBM (Xiao et al., 2021).

Structural interventions are a diverse category of approaches 'thatwork by altering the context in which health is produced and reproduced' (Blankenship et al., 2000, p.11). Blankenship et al. (2000) have proposed a systematic framework to organize structural interventions along two dimensions: the source of the problem, which may be related to availability, acceptability or accessibility of behaviours, resources (i.e., tools, equipment, materials), or settings (i.e., the services provided); and the social-ecological level at which interventions are targeted (i.e., individual, organizational, environmental). Auerbach et al. (2011) describe structural interventions for HIV prevention as including the following: policy-legal changes (e.g., decriminalization of homosexuality), environmental enablers (e.g., increasing access to condoms, PrEP), changing harmful social norms (e.g., addressing stigma and discrimination), facilitating social and political change (e.g., policy dialogue, advocacy), empowerment of communities and groups (e.g., community building, developing leadership), and economic interventions (e.g., monetary incentives, microcredits). Structural interventions to mitigate social stigma or address gendered socioeconomic inequities have gained

particular prominence in the global HIV response. A comprehensive review of economic interventions globally found that approaches that combined economic strengthening (e.g., microcredits) with gender transformative components (e.g., group discussions, couples interventions) generally had positive effects on HIV-risk behaviours, while mixed effects were found for interventions that only addressed economic strengthening, and effects for unconditional cash transfers were non-significant or positive (Gibbs et al., 2017).

Social stigma affects all aspects of the HIV response, and Nyblade et al. (2021) conclude from their scoping review that evidence for how to mitigate HIV-related stigma has increased. A review and meta-analysis of US-based interventions for MSM found that inclusion of a stigma reduction component could decrease sexual risk behaviours and possibly increase HIV testing, although no overall changes were found in self-reports of stigma and the studies were diverse in study population, delivery methods and intervention content (Gunn et al., 2021). Stigma reduction interventions may be most effective in changing HIV-related risk and prevention behaviours if they assess the immediate, actionable drivers of HIV-related stigma (i.e., raise awareness, address fears and misconceptions, and challenge shame and blame), centre affected groups at the core of the response (i.e., develop and strengthen networks, empower and strengthen capacity, and address internalised stigma), and engage opinion leaders and establish partnerships with affected groups (i.e., contact strategies, empathy building, modelling desirable behaviours, recognise and reward role models) (for a more extensive description, see Nyblade et al., 2021). Furthermore, a realist review of HIV-stigma reduction interventions for MSM found that these can be successful in reducing stigma through intrapersonal (e.g., self-acceptance), interpersonal (e.g., empowerment) and structural strategies (e.g., community leader sensitization) (Dunbar et al., 2020).

Conclusions

STIs, including HIV, remain a major public health concern globally (e.g., Vos et al., 2016), especially for key affected groups such as young people and MSM. The current review highlights the many important contributions the behavioural sciences, in particular health psychology, make to STI control. Behavioural science contributions are most evident in, and perhaps synonymous with, behaviour change interventions to reduce sexual risk and promote protective sexual behaviours. In recent years, these once acclaimed approaches are, however, considered insufficient, and perhaps unnecessary, for effective STI control (e.g., Padian et al., 2010), while biomedical approaches relying on testing, treatment pre-exposure prophylaxis and vaccination came to prominence (e.g., Flash et al., 2012), and the importance of structural interventions to alter the context in which behaviours are enacted is well-recognised (e.g., Auerbach et al., 2011). However, all STI control approaches continue to rely on behaviour change (Kippax & Stephenson, 2012), not only of affected communities but also of environmental agents, that is, the individuals or groups (e.g., policymakers, health service providers) who control aspects of the environmental conditions (Kok et al., 2017), in particular the availability, acceptability and accessibility of services, devices and supports that enable STI prevention behaviours.

Important continuing and novel roles remain for behavioural and social sciences in STI control, including as part of biomedical approaches. A functional framework of behavioural and social science research (BSSR) in the HIV responses, which can be extended to STI control more broadly, distinguishes four primary domains of contribution (Gaist & Stirratt, 2017). Firstly, BSSR is critical to understanding the behaviours and contexts that are related to STI risk and vulnerability (i.e., basic BSSR). Secondly, BSSR is essential to improve behavioural and social intervention approaches to reduce risk and promote prevention and care, including treatment (i.e., elemental BSSR). Thirdly, BSSR contributes to strengthening the design and outcomes of biomedical trials (i.e., supportive BSSR) in various ways. These include formative research, embedded or parallel research into separate but related questions or provide understanding of the context and its influences, and post-trial assessments of explanations or implications of findings (Corneli et al., 2019). Fourthly, BSSR contributes key components for integrative prevention and treatment approaches (i.e., integrative BSSR), also referred to as combination prevention (see Coates et al., 2008).

Behavioural (e.g., Coates et al., 2008) and social scientists (e.g., Kippax & Stephenson, 2012), nevertheless, agree that behavioural prevention science and practice can do better. Parkhurst (2014) more specifically noted that 'much HIV prevention activity has occurred without sufficient conceptualization of why or how a particular approach should actually bring about a sustained change in behaviour in a given setting' (p. 11) and pointed to three key objectives for future behavioural STI prevention efforts. These should address broader structures that shape behavioural risk and vulnerability, tailor responses to the factors that affect risk and vulnerability of the target population, and address multiple factors as needed (Parkhurst, 2014). Building on this analysis of lessons learned, we identify seven interrelated challenges and opportunities for health psychologists and other health behaviour scientists to contribute to strengthening STI prevention and health promotion more generally.

Firstly, as already signalled in the early years of the HIV response (see Fishbein, 2000), there is a continuing need for integration of the multitude of similar and overlapping social-cognitive models of behaviour, to ensure a conceptual consensus to guide behaviour change approaches. An important initiative in the early 2010s organized the wide diversity of conceptual constructs into a limited number of overarching theoretical domains (e.g., Cane et al., 2012). Also, an integrated behavioural system was proposed, specifying motivation, capability, and opportunity as essential conditions for behaviour change (Michie et al., 2011). However, these conceptual frameworks remain within the social-cognitive theoretical tradition that sees individuals' beliefs and perceptions as proximal influences on behaviour that are assessed at the individual level. A second, related challenge and opportunity is hence to develop a truly multilevel social-ecological model of behaviour in which proximal determinants are embedded and that specifies the processes and mechanisms linking individual, social and structural levels of influence (cf. Kaufman et al., 2014).

A third challenge and opportunity for health psychologists and other behaviour change experts is to improve the specification, use and evaluation of behaviour change techniques (BCTs) for the prevention of HIV and other STIs (Johnson et al., 2014). BCTs constitute the smallest active intervention components, and potentially relevant BCTs are specified in emerging taxonomies (e.g., Michie et al., 2013). A fourth challenge/

opportunity is to provide guidance on the use of BCTs with environmental agents at social and structural levels of influence, and to extend taxonomies to include specifications of additional behaviour change approaches to specifically target these higher levels of influence, which may be derived from sociological and other social science theories. Fifthly, behavioural interventions can be strengthened by advancing understanding and evidence regarding the tailoring of BCTs to the factors that are found to shape behaviours of specific population groups in specific settings (cf. Michie et al., 2011). A recently developed online tool aims to provide practical guidance to link BCTs to determinants of behaviour, or mechanisms of action (Johnston et al., 2021), albeit that the focus is on individual-level factors and processes. Sixthly, behavioural interventions should not address people as just individuals, but as connected members of groups, networks, and communities, and encompass developing community capacity, including for collective action (Kippax, 2012). A seventh, and last, challenge and opportunity is to strengthen the use of proven approaches for the systematic planning of health promotion interventions, such as the Intervention Mapping protocol (e.g., Kok et al., 2017). Intervention Mapping and other program planning protocols provide guidance for the participatory development of ecological, theory- and evidence-based interventions, which contribute to addresses many, if not all, of the preceding challenges.

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