CSIRO PUBLISHING
Sexual Health, 2017, **14**, 5–17
http://dx.doi.org/10.1071/SH16070

Review

HIV incidence among gay men and other men who have sex with men in 2020: where is the epidemic heading?

Shauna Stahlman[A,F], *Carrie Lyons*[A], *Patrick S. Sullivan*[B], *Kenneth H. Mayer*[C,D], *Sean Hosein*[E], *Chris Beyrer*[A] *and Stefan D. Baral*[A]

[A]Johns Hopkins Bloomberg School of Public Health, Center for Public Health and Human Rights, Department of Epidemiology, 615 N. Wolfe Street, Baltimore, MD 21205, USA.
[B]Department of Epidemiology, Rollins School of Public Health, Emory University, 1518 Clifton Road, Atlanta, GA 30322, USA.
[C]Fenway Health, The Fenway Institute, 1340 Boylston Street, 8th floor, Boston, MA 02215, USA.
[D]Division of Infectious Diseases, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Avenue, Boston, MA 02215, USA.
[E]CATIE (Canada's AIDS Treatment Information Exchange), 555 Richmond Street West, Suite 505, Box 1104, Toronto, ON M5V 3B1, Canada.
[F]Corresponding author. Email: sstahlm1@jhu.edu

Abstract. The goal to effectively prevent new HIV infections among gay, bisexual, and other men who have sex with men (MSM) is more challenging now than ever before. Despite declines in the late 1990s and early 2000s, HIV incidence among MSM is now increasing in many low- and high-income settings including the US, with young, adolescent, and racial/ethnic minority MSM being among those at highest risk. Potentiating HIV risks across all settings are individual-, network-, and structural-level factors such as stigma and lack of access to pre-exposure prophylaxis (PrEP) and antiretroviral treatment as prevention. To make a sustained impact on the epidemic, a concerted effort must integrate all evidence-based interventions that will most proximally decrease HIV acquisition and transmission risks, together with structural interventions that will support improved coverage and retention in care. Universal HIV treatment, increased access to HIV testing, and daily oral PrEP have emerged as integral to the prevention of HIV transmission, and such efforts should be immediately expanded for MSM and other populations disproportionately affected by HIV. Respect for human rights and efforts to combat stigma and improve access to prevention services are needed to change the trajectory of the HIV pandemic among MSM.

Received 30 April 2016, accepted 7 June 2016, published online 5 August 2016

Introduction

Gay, bisexual, and other men who have sex with men (MSM) continue to be among those at highest risk for HIV. Globally, HIV incidence among MSM has peaked, including in regions with the most broadly generalised HIV epidemics, such as Southern and Eastern Africa, where the annual number of new HIV infections among adults has declined by 34% since 2001.[1] These gains have been achieved through improved coverage and implementation of HIV prevention and diagnostic approaches, combined with increased access to antiretroviral therapy (ART).[2] In 2014, The Joint United Nations Programme on HIV/AIDS (UNAIDS) released the 90–90–90 targets as guidelines to scale-up HIV testing and treatment, with the objective of reaching 90% of people living with HIV to know their status, 90% of people diagnosed with HIV to receive sustained antiretroviral therapy (ART), and 90% of people receiving ART to achieve viral suppression.[3] Indeed, there have been marked improvements in expansion of HIV testing and treatment coverage in recent years, although the persistently high HIV incidence among MSM suggests the need for continued work to optimise HIV treatment outcomes.[1,4,5]

The bar to effectively prevent HIV among MSM is higher than that of most other populations given the rapid transmission potential in MSM networks and structural barriers impeding engagement in care. It can be argued that a HIV pandemic exists among MSM in that from every country where quality data are available, there is continued sustained incidence.[6,7] To quantify this disproportionate burden, a review of 21 countries with concentrated epidemics demonstrated that the pooled odds ratio of HIV infection among MSM was estimated to be 25.5 when compared with other adults, and 10.8 across nine countries with more generalised epidemics.[8] Incidence data available as of 2016 reinforce this narrative in that incidence measures from cohorts of MSM in higher income settings and more concentrated

epidemics are high and sustained, and incidence data from low- and middle-income countries are similarly stable or increasing.[7,9–21]

In order to better understand the factors associated with the incidence density of HIV among MSM, this paper will: (1) review the geographic trends in HIV incidence; (2) focus on specific epidemiological subgroups (e.g. young MSM); (3) discuss the factors that potentiate the intensifying epidemics among MSM; and (4) discuss the promise of new prevention technologies in achieving epidemic control.

Current HIV incidence data among men who have sex with men in high-income settings

In order to describe the changes in HIV incidence that have taken place among MSM, we first introduce the reproductive rate of infection (R_0), which is the average number of secondary infections produced by one HIV-infected individual.[22] For sexual transmission of HIV, R_0 depends on the probability of transmission per coital act (β), and the number of unprotected coital acts with different sex partners, also known as the contact rate (c), and the average duration of infectiousness (D).[22] In the late 1990s and early 2000s, there were tangible HIV incidence declines among MSM across several high income countries – including Australia, France, the UK, and the US.[20] This was also a time of great loss and fear in gay communities given the high mortality rates before the scale up of effective ART, then referred to as highly active antiretroviral therapy (HAART). This resulted in reductions in the absolute number of MSM and decreased contact rate between MSM (c), as well as increased condom use, which reduced the probability of transmission (β). After the introduction of HAART, HIV slowly evolved into a chronic disease and one that was far less likely to be overtly symptomatic. New cohorts of MSM came of age in a period where HIV was no longer a death sentence, and some started having condomless anal sex without the intense fear of mortality related to HIV infection. Subsequent to this, the growing popularity of online sex-seeking and geo-spatial social networking applications has resulted in easy access to high numbers of instantaneous sexual partners.[23–27] Once again, this has increased contact rates between MSM as well as probably of HIV transmission, thereby driving HIV incidence among MSM in recent years.

In the US, new HIV infections have increased among young MSM by ~10% per year since 2002 in the context of an otherwise stable or declining HIV epidemic in other populations.[28] The estimated number of new HIV infections among MSM in the US increased by 12% from 2008 to 2010, from 26 700 to 29 800 infections.[29] Consequently, the per cent of all HIV infections among men attributable to male-to-male sexual contact increased from 63% to 78%.[29] With growing HIV incidence, the racial disparities in the burden of HIV among MSM, now understood to be largely secondary to socioeconomic determinants of HIV, became increasingly marked from 2002 to 2011.[28,30,31] Notably, the US is estimated to account for over 30% of total infections in high-income countries with now consistently demonstrated disparities across income levels, and along ethnic and racial lines.[20,32] While the US has a higher absolute burden, similar sociodemographic trends have also been observed in several other countries.

In Canada, the HIV incidence rate was 443 per 100 000 among MSM and 6.2 per 100 000 among men who do not have sex with men, making MSM 71-fold more likely to acquire HIV[33] (Table 1; Fig. 1). Both of these estimates are conservative, given that they rely on self-reported status of being gay or otherwise MSM as part of a HIV surveillance system driven primarily by passive case-based HIV surveillance, and are likely to be underreported because some MSM may not be comfortable in discussing their behaviours.

The trend of increasing incidence among MSM extends to other high-income countries outside of North America. In Australia, 70% of HIV diagnoses in 2014 were attributed to male–male sexual contact.[34] In the United Kingdom, new HIV diagnoses among MSM rose annually from 1440 in 1999 to 3250 in 2013.[35] The ITACA cohort of 3544 MSM established in Barcelona, Spain, noted an overall HIV incidence of 2.4 per 100 person-years, with foreign born men being at increased risk for infection.[157] During the study period, HIV incidence increased from 1.2 to 3.1 person-years from 2009 to 2011.[157] Finally, in a report from 30 European Union (EU)/European Economic Area (EEA) countries, the highest proportion of new HIV diagnoses in 2012 continued to be reported among MSM (40%; 11 877 cases).[37]

Men in higher income settings have three primary HIV acquisition risks including parenteral drug use, heterosexual transmission and through same-sex practices. In many high-income settings, needle and syringe exchange programs exist, with some places also having safe drug consumption facilities to minimise the reuse of potentially contaminated injecting devices.[38–40] When given the option, the uptake of harm-reduction approaches among people who use drugs is extremely high. In general, men have a lower HIV acquisition risk when having sex with women because of lower transmission probabilities in penile-vaginal sex, as well as fewer female sexual partners and concurrent partnerships, resulting in a smaller sexual network.[41,42] These specific acquisition risks have also decreased with increased coverage of ART for women living with HIV in many higher income settings. Together, these factors have lowered HIV incidence among men who do not have sex with other men over the past decade, but appear to have not affected MSM.

Current HIV incidence data among men who have sex with men in low- and middle-income settings

In the earlier years of the HIV pandemic, there was a widely held misconception that HIV among MSM was an issue restricted to high-income countries. More recently, improved HIV surveillance in low- and middle- income countries (LMIC) has identified major epidemics among MSM.

A study conducted in Kenya observed incidence of 6.8 per 100 person-years in a cohort of MSM from 2005 to 2008.[16] In Thailand, the estimated HIV incidence among MSM in Bangkok increased from 4.1% in 2003 to 7.7% in 2007.[43] Another study conducted in Bangkok observed an overall HIV incidence of 5.9 per 100 person-years from 2006 to 2012,[44] whereas in northern Thailand, HIV incidence among a cohort

Table 1. HIV incidence among men who have sex with men (MSM)

BED-CEIA, BED-enzyme immunoassay; EIA-RI, enzyme immunoassay for recent HIV-1 infection; N/A, not available; STD, sexually transmissible disease; STIs, sexually transmissible infections; NPEP, non-occupational post-exposure prophylaxis

Country	MSM or subpopulation	Income setting	Incidence per 100 person-years	Sample size (*n*)	Data collection year(s)	Note	Reference
Argentina	MSM sex workers	High	6.06	N/A	2006–2009		136
Argentina	MSM	High	6.33	262	2006–2009		136
Australia	MSM	High	0.81	N/A	2014	STD clinic sample	137
Brazil	MSM	Low, middle	2.5	1085	1994–2010		138
Canada	MSM	High	0.443	N/A	2011		33
China	MSM	Low, middle	2.9 (year 2005); 3.6 (year 2006)	1067	2005–2006	BED-CEIA estimate	139
China	MSM	Low, middle	7.01 (year 2006); 7.98 (year 2007); 7.80 (year 2008)	2898	2003–2006	BED-CEIA estimate	140
China	MSM	Low, middle	3.5	378	2009–2011		141
China	MSM	Low, middle	6.78	622	2009–2010		142
China	Migrant MSM	Low, middle	7.83	511	2009–2010		143
China	MSM	Low, middle	5.6	725	2009–2012		144
China	MSM	Low, middle	5.9	1003	2009–2012		145
China	MSM	Low, middle	3.9	962	2009–2010		146
China	MSM	Low, middle	4.23	661	2013		147
China	MSM	Low, middle	5	N/A	2010–2015	Pooled incidence from 24 studies	11
El Salvador	MSM	Low, middle	3.6	347	2001–2002		148
France	MSM	High	3.8	886	2009	EIA-RI estimate	149
Guatemala	MSM	Low, middle	2.1	158	2001–2002		148
Honduras	MSM	Low, middle	4.9	332	2001–2002		148
India	MSM	Low, middle	1.8	1126	2009–2010		150
Italy	MSM	High	5.2 (year 1986); 9.2 (year 1992); 1.3 (year 2001); 11.7 (year 2009)	1862	1986–2009	STD clinic sample	151
Kenya	MSM	Low, middle	6.8	327	2005–2008		16
Kenya	MSM	Low, middle	7.5	N/A	2005–2012		152
Kenya	MSM	Low, middle	8.6	449	2005–2011		153
Netherlands	MSM	High	8.6 (year 1985); 1.3 (year 1992); 2.0 (year 2009)	1642	1985–2009		154
Nicaragua	MSM	Low, middle	14.4	171	2001–2002		148
Panama	MSM	Low, middle	2.7	409	2001–2002		148
Peru	MSM	Low, middle	3.6	510	2009–2012		36
Portugal	MSM	High	2.8	804	2011–2014		155
Senegal	MSM	Low, middle	16	40	2011–2012		156
Spain	MSM	High	2.4	3544	2008–2011	Community-based cohort	157
Thailand	MSM	Low, middle	4.1	308	2003		15
Thailand	MSM	Low, middle	6.4	94	2005		15
Thailand	MSM	Low, middle	7.7	99	2007		15
Thailand	MSM	Low, middle	8.2	551	2008–2009		45
Thailand	MSM	Low, middle	5.9	1744	2006–2012		44
Thailand	MSM	Low, middle	6.3	4762	2005–2011		158
Thailand	Young MSM (15–21 years old)	Low, middle	12.2	662	2005–2011		158
United Kingdom	MSM	High	0.45	N/A	1998–2010		17
United States	MSM	High	1.9	4295	1999–2003		159
United States	Young Black MSM (18–24 years old)	High	5.1	678	2008		160
United States	Black MSM	High	3.0	1164	2009–2010		161
United States	MSM	High	6.7	276	2008–2010	Among those with rectal STIs	162

(*continued next page*)

Table 1. (*continued*)

Country	MSM or subpopulation	Income setting	Incidence per 100 person-years	Sample size (*n*)	Data collection year(s)	Note	Reference
United States	Black MSM	High	15.34	51	2008–2010	Among those with rectal STIs	162
United States	Young MSM (<20 years old)	High	10.46	30	2008–2010	Among those with rectal STIs	162
United States	Young MSM (18–19 years old)	High	2.85	594	2009–2011		163
United States	MSM	High	0.7	386 (year 2004); 521(year 2008)	2004, 2008	Estimated using closed population model	164
United States	MSM	High	2.2	894	1997–2013	Among NPEP users	165
United States	MSM	High	0.6	510 (year 2011); 411 (year 2014)	2011, 2014	Estimated using closed population model	164
United States	MSM	High	1.6	6577	2007–2013	Among those with STIs	166
United States	Black MSM	High	4.16	2898	1994–2010	Weighted estimate	55
United States	MSM	High	3.8	562	2010–2012		31
United States	Black MSM	High	6.5	260	2010–2012		31
United States	Young Black MSM (16–20 years old)	High	6.18	571	2009–2015		47
United States	Young MSM (16–20 years old)	High	4.11	450	2009–2015		47

Fig. 1. HIV incidence per 100 person-years among men who have sex with men (MSM). Data are from Table 1. In the case of multiple incidence estimates per county, only data from the most recent study were included.

of MSM was estimated to be 8.2 per 100 person-years from 2008 to 2009.[45] In a cohort of 510 MSM in Lima, Peru, the HIV incidence was 4 cases per 100 person-years, further indicating high risk as compared with other adults.[36] Furthermore, a 2012 review of 55 studies among MSM in China found a dramatic 3.3-fold increase in HIV incidence among MSM from 2.04 to 7.02 per 1000 person-years during 2002–2010.[46]

Taken together, these data suggest that HIV incidence is more similar than different across varying income levels of countries. Indeed, the similarities of HIV incidence levels among MSM also extend to countries with very distinct HIV epidemics, reinforcing the unique nature of HIV epidemics among MSM.[7]

HIV incidence among young MSM

The highest HIV incidence rates in many settings appear to be among younger age groups of MSM.[19,47–49] In an Atlanta cohort, MSM aged 18–24 years had 2.5-fold the risk of acquiring HIV as compared with older MSM.[31] These high incidence rates are sustained as evidenced by an earlier cohort conducted from 1996 to 2000 in Baltimore among young MSM aged 15–29 years, which revealed a HIV incidence of 4.2% per year.[50] In the UK, the largest increases in new HIV diagnoses from 1999 to 2013 occurred among young MSM aged 15–24 years (16% of new diagnoses).[35] HIV incidence

among MSM who are 18–21 years old in Thailand is 8.8 per 100 person-years compared with 5.9 per 100 person-years among all MSM from 2006 to 2012.[44] Furthermore, a report including 15 EU member states found that the largest increase in new HIV infections occurred among young MSM aged 20–29 years, with the number of cases almost doubling from 2003 to 2012 (1037 to 1881 cases; 81% increase).[37]

HIV incidence among racial and ethnic minorities

In the US, HIV incidence disproportionately affects Black and Hispanic MSM and most severely young Black MSM.[9,29,51–55] The Centers for Disease Control and Prevention (CDC) estimated, using data from 2009 to 2013, that one in two Black MSM and one in four Hispanic MSM will be diagnosed with HIV in their lifetime, compared with 1 in 11 White MSM and 1 in 132 White men.[56] In a cohort study of young MSM in Chicago, the highest incident rate recorded was among young Black MSM, with an incidence of 6.2 infections per 100 person-years compared with 2.9 infections per 100 person-years among Hispanic young MSM and 0.9 infections per 100 person-years among young White MSM in the same cohort.[47] In an Atlanta cohort of 260 Black and 302 White MSM, there was an overall incidence of 3.8 per 100 person-years, with a higher rate among Black (6.5 per 100 person-years) as compared with White MSM (1.7 per 100 person-years).[31] Similarly, in the Baltimore Young Men's Survey, there were substantial racial differences in HIV incidence, with 11.0% per year (95% CI: 5.5–19.7) among non-Hispanic Blacks, 7.1% among 'other' or mixed race participants (95% CI: 2.9–14.6) and 0.6% among non-Hispanic Whites (95% CI: 0.002–4.9).[50] Although the majority (85%) of new HIV cases in the UK were from White MSM, there has been a significant year-on-year increase in diagnoses among Asian and Black African MSM.[35]

What sustains HIV incidence among MSM in the context of a slowing HIV pandemic?

Many studies about HIV in MSM have focused significantly on the measurement of a range of individual determinants of HIV infection among MSM such as condomless insertive and receptive anal intercourse with serodiscordant and viremic sexual partners, high frequency of casual male partners, and drug use, including the use of amphetamines and other substances before and during sex.[57] This latter phenomenon has been well documented in the UK and is known as 'chemsex', referring to the sex between men that occurs under the influence of disinhibiting drugs and particularly 'club drugs' such as ecstasy, cocaine or ketamine.[58] Furthermore, online sex-seeking is increasing among MSM in both low- and high-income settings, which presents increased opportunity for HIV exposure given increased access to sexual partners.[25,59,60] Asymptomatic bacterial sexually transmissible infections may also play a role in potentiating HIV acquisition and transmission among MSM through genital tract inflammation involving increased local density of immune cells that are at risk for acquiring HIV, ulcerations and abrasions.[61–63]

However, beyond individual behaviours, there are other forces driving the disproportionate HIV burden among MSM (Fig. 2), including biologically mediated factors. At the network-level, there is a far higher per-act and per-partner transmission probability of HIV from receptive anal sex[7,64–66] when compared with vaginal sex or insertive penile sex. Acquisition rates for receptive condomless anal sex between men and women do not vary greatly, as they depend on the biology of the virus and the physiology and immunology of the intestinal tract. However, transmission rates within networks vary greatly as men can be either the insertive or receptive partner during sex; that is, by efficiently acquiring HIV and then efficiently transmitting it. This sexual role versatility, coupled with the high per-act risk of HIV transmission during rectal exposure, leads to high

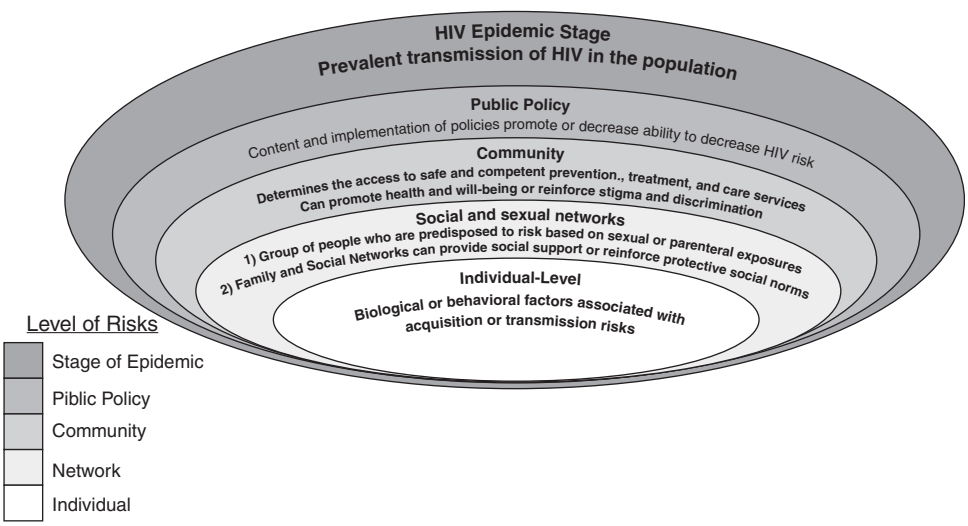

Fig. 2. Modified social ecological model for levels of HIV risk among men who have sex with men (MSM). This Figure is licenced under a Creative Commons Attribution 4.0 International Public Licence (http://creativecommons.org/licenses/by/4.0/legalcode).[135]

individual, couple-based and network-level HIV transmission risks.[67–69]

Individual behavioural risk factors do not appear to explain the increased risk for HIV among Black MSM in the US or among racial/ethnic minorities in other settings.[32,54] Instead, research has pointed to higher network-level transmission risk including high prevalence of STIs and HIV in Black sexual networks, socioeconomic factors and higher levels of undiagnosed infection.[31,54,70] Currently, young MSM including young Black MSM in the US are less engaged in HIV testing, less likely to be aware of their infection and more likely to unknowingly transmit the virus to others.[32,71,72] In addition, structural risk factors for young MSM such as limited engagement in sexual health education, complex parental consent laws for HIV testing and treatment, as well as lack of privacy for those on their parents' health insurance, complicate programmatic initiatives. Moreover, it is difficult to study the needs of adolescent gay men and other MSM given the ethical and legal limitations in including these populations in research studies.[73–75] HIV risks are further potentiated by serodiscordant partnerships with older men and limited awareness and uptake of HIV preventive services.[72,73,76] In high-income settings in particular, improved treatment has allowed many living with HIV to lead longer and healthier lives. Because of this, many MSM and particularly younger generations may perceive HIV as less dangerous and are not as knowledgeable about or engaged in prevention services.[74]

Further potentiating the biological drivers of HIV acquisition and transmission in all settings are the multiple forms of stigma affecting MSM that limit the provision and uptake of HIV prevention, treatment, and care services.[77–79] Exposure to stigma including culturally insensitive health workers can result in MSM avoiding HIV testing and other prevention services, limiting diagnosis and awareness of status.[78,80–82] Even more acute, men who are aware of living with HIV may avoid HIV treatment altogether.[83] Reduced utilisation of health and HIV services by MSM, due to enacted or perceived discrimination, limits knowledge of the risks of condomless anal intercourse and opportunities for access to prevention services.[78,81]

Much of the stigma measurement for gay men has focused on internalised stigma or internalised homonegativity.[84–88] However, recent studies demonstrating the high levels of experienced and perceived stigma in countries ranging from Europe to Sub-Saharan Africa suggest that internalised stigma is an outcome of lived stigma and may be a proxy for mental health stressors related to this stigma.[80,89–93] Indeed, mental health issues appear consistently as outcomes of stigma and as a mediating determinant of HIV risks.[94–96] Given the efficient HIV transmission that can take place in sexual networks of MSM if a network member is acutely infected, stigma limiting engagement in services is problematic given that it can contribute to late HIV diagnoses.[20,97]

Where sufficient HIV surveillance systems are in place, late diagnoses have been found to be sustained or increasing in high-income settings. As with HIV incidence, data suggest an even higher burden of late diagnoses among racial/ethnic minority MSM secondary to HIV stigma and limited social support.[98–100] Breaking chains of HIV transmission necessitates not just coverage of HIV testing, but the diagnosis of people during the acute and early infection stages followed by effective and sustained intervention. Thus, universal HIV treatment approaches are challenged in terms of optimising clinical outcomes and eliminating onward HIV transmission in the context of late diagnoses.[20]

Changing the future: what will it take to change the trajectory of HIV incidence by 2020?

A concerted effort rooted in evidence and affirming of human rights is needed to truly change the trajectory of the HIV pandemic among MSM. One high bar has already been set – the Commission for AIDS in Asia has suggested that comprehensive packages of HIV prevention interventions should cover between 60 and 80% of MSM in order to make an impact on the HIV epidemic.[101] In addition, effective control of the HIV epidemic will also require a strong public health system with improved surveillance, epidemiology and disease control activities for MSM, particularly in many LMIC settings. The role of public health policy moving forward will be to utilise lessons learned from jurisdictions that have been successful in reducing HIV incidence among MSM. For example, King County in Washington, USA experienced a decline of 26% in new HIV diagnoses among MSM from 2004 to 2013, with an even greater decline among Black MSM (44%).[102] These trends are thought to be the result of having a well-developed public health infrastructure including community-based organisations, medical providers, academia, and state and local health departments, as well as low levels of stigma towards MSM in the region.[102]

Across all settings, developmental indicators are needed for MSM, including measurement of the rates of uptake and engagement in early diagnosis and treatment, pre-exposure prophylaxis (PrEP), in addition to programs to address HIV-related and sexual behaviour-related stigma. Better understanding of the mechanisms by which stigma and mental health influence health disparities of MSM is needed, and validated and consistent metrics of stigma will be necessary for completing this task. The world has fortunately observed declines in new HIV infections; however, this has been accompanied by a slowly increasing concentration of the virus among MSM. A concerted effort must integrate the evidence-based interventions that will most proximally decrease HIV acquisition and transmission risks, together with the structural interventions that will support improved coverage and ultimately retention of these services. Fortunately, there are data finally supporting novel approaches that may actually allow for these incidence reductions to be realised.[103,104]

In 2010, the iPrEx (Pre-exposure prophylaxis initiative) trial demonstrated a 44% reduced HIV incidence among MSM in the Truvada-based (tenofovir–emtricitabine) PrEP arm compared with the placebo arm.[105] Two subsequent studies, PROUD (Pre-exposure prophylaxis to prevent the acquisition of HIV-1 infection) and iPERGAY (Intervention Préventive de l'Exposition aux Risques avec et pour les Gays), demonstrated 86% efficacy when MSM knew that adherence to PrEP would be

protective.[106,107] Of paramount importance was the finding that when men had sufficient levels of intracellular tenofovir diphosphate, secondary to the actual use of the drug, protection from HIV infection was complete. This has fundamentally changed the response to and transitioned the focus of study to how best to support adherence to PreP. Unfortunately, HIV incidence is highest in youth while medication adherence is also lowest in this population.[103,108–110] The US-based Adolescent Trials Network (ATN) supported a study, ATN110, suggesting feasibility and safety in a PrEP study among young MSM aged 18–22 years as part of Project PrEPare; however, low adherence levels (63.4% detectable tenofovir at week 4 and 20% at week 24) confirmed that the most challenging aspect of this is sustained adherence.[111] In addition, adherence and effectiveness of PrEP was lowest among the Black adolescents in the trial, suggesting a potential need to reduce racial disparities in adherence rates.[111]

Additional studies have confirmed that PrEP is now a part of primary HIV prevention services that should be offered to MSM.[106,107,112] However, in early 2016, PrEP is implemented and recommended for MSM in only a few countries including the US, South Africa, France, Israel, Canada and Kenya, highlighting the disconnect between the evidence and the implementation of this approach.[113] The UK, where the PROUD study demonstrated high effectiveness,[107] has decided not to implement PrEP through the UK's National Health Service despite strong interest in PrEP among gay men and providers.[114] This slow and uneven implementation arguably reveals the challenges of advocating for the scale-up of an intervention that is based on efficacy and effectiveness data primarily from gay men and other MSM. Development of new formulations of oral PrEP and of topical and long-acting injectable PrEP are likely to continue to improve the side-effect profile, dosing strategies and ease of adherence to these interventions. Price reductions for Truvada and related tenofovir formulations are also called for, given that cost-effectiveness arguments have been common in country decisions not to implement PrEP.

However, PrEP in its current form and cost is necessary but may not be sufficient to reduce HIV incidence among MSM, given the limited access and challenges in terms of adherence.[115] Getting PrEP to the younger MSM, particularly minors who may need parental consent, will be a particular challenge in many settings. But PrEP does fit well within a rubric of combination HIV prevention that leverages a package of biomedical, behavioural and structural interventions addressing multiple layers of risk.[103,115–118] Combination approaches including biomedical, behavioural and structural components, are likely to be even more efficient to address the needs of MSM with acute HIV acquisition risks.[17,119–121] Biomedical components include PrEP and universal linkage to ART to optimise clinical outcomes and decrease onward HIV transmission, whereas behavioural components are included to facilitate uptake and sustained engagement in these biomedical interventions, and continued use of counselling about condoms, condom compatible lubricants and regular HIV testing. Structural interventions are those that will support optimal implementation and higher coverage including clinical and cultural competency training for health providers and meaningful stigma mitigation approaches. These combination approaches are particularly underutilised for MSM across many LMIC including across Sub-Saharan Africa where many programs consist of peer education and condom distribution with limited attention to the discriminatory policies and stigma affecting MSM.[116,117] The 2012 Global Men's Health and Rights Study, which included data from a global online survey of 5779 MSM from 165 countries, indicated that overall 41.5% of respondents reported complete access to HIV treatment and only 26.5% were from Sub-Saharan Africa.[122] Ultimately, the challenge will be not just linking people to a range of effective services, but will be about securing long-term retention – and this will require significant research leveraging the best implementation research approaches.

Given the rapid HIV transmission within sexual networks of MSM, meaningful combination prevention necessitates rapid HIV diagnosis. Fourth-generation HIV tests, which are better suited for detecting recent infection, are recommended for routine use in the UK.[123] However, evaluating approaches to further decentralise HIV testing, including HIV self-testing (HIVST), may further decrease the time between HIV exposure, infection and diagnosis. HIVST may take a range of different forms, but does facilitate screening for HIV in private and may also facilitate reaching the currently 'unreached' MSM.[124] The Internet and mobile technologies also have far-reaching potential to reduce HIV incidence among MSM by 2020.[125–127] Internet-based interventions have ranged from providing information via SMS text to supporting adherence to HIV medication by using gamification methods, and continue to be developed as technology expands.[127,128] However, challenges remain regarding effective implementation of these approaches and ensuring linkage to ART after a positive diagnosis.

There are a range of additional biomedical prevention strategies under development, such as rectal microbicides and an HIV vaccine, which would also offer protection against rising HIV incidence.[129,130] More than 250 clinical trials for the HIV/AIDS vaccine have been conducted to date with significant supportive evidence from *in vitro* and animal model research.[131] In addition, there were some signs of success associated with the RV-144 Thai Vaccine study, with attention currently being given to understanding that success and leveraging it.[131] A subsequent trial of the RV-144 regimen among MSM in Thailand is currently in development – and this will be critical, because the efficacy of protection with this prime-boost regimen for rectal exposure is currently unknown. The most recent studies to be launched in this arena are based on broadly neutralising antibodies aiming to target conserved epitopes across different HIV strains.[132–134] Even in the best case scenario, we are more than a decade away from any actual HIV vaccine product being used in real world settings and thus, will not be able to significantly modify HIV incidence by 2020.[131]

Conclusions

There is a pandemic of HIV among gay men and other MSM, and HIV is increasingly concentrating within this population.

Historical data tell us that this pandemic will continue to grow well past 2020 unless a concerted and global effort is effectively brought to scale for MSM. Globally, we will need improved public health systems, HIV surveillance mechanisms and meaningful indicators to support the evaluation of programs in changing the trajectory of this pandemic by 2020. Moreover, evidence-based and human-rights affirming interventions are needed to address the structural level risk determinants including stigma in communities, punitive laws and policies and exclusion from national HIV responses that generally limit the provision and uptake of efficacious interventions. Universal provision of HIV treatment, fourth generation HIV tests, HIV self-testing and daily oral PrEP have emerged as being integral to the prevention of acquisition and transmission of HIV. Now they need to be equitably scaled to also minimise the disparities that exist within communities of gay men and other MSM in so many settings around the world. Given the biology of HIV, the bar for HIV prevention among gay men and other MSM is extremely high. Changing the trajectory of HIV incidence among gay men and other MSM demands truly respecting and working to understand all of those we aim to serve, to increase the chance that we actually do.

Conflicts of interest

Chris Beyrer is receiving a donation of Tenofovir/Emtricitabine (Truvada) from Gilead, Inc. for an effectiveness study of a multi-level combination HIV preventive intervention with and without daily oral Truvada pre-exposure prophylaxis among young men who have sex with men in Bangkok, Thailand (R01AI118505; PI: Beyrer). Kenneth H. Mayer has received unrestricted research grants from Gilead Sciences and ViiV Healthcare. Shauna Stahlman, Patrick S. Sullivan, Sean Hosein and Stefan D. Baral declare that they have no conflicts of interest.

Acknowledgements

This publication was made possible with help from the Johns Hopkins University Center for AIDS Research, an NIH-funded program (P30AI094189), which is supported by the following NIH Co-Funding and Participating Institutes and Centers: NIAID, NCI, NICHD, NHLBI, NIDA, NIMH, NIA, FIC, NIGMS, NIDDK and OAR. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

References

1 UNAIDS. Global report: UNAIDS report on the global AIDS epidemic 2013. Geneva: Joint United Nations Programme on HIV/AIDS; 2013.

2 MacAllister J, Sherwood J, Galjour J, Robbins S, Zhao J, Dam K, *et al*. A comprehensive review of available epidemiologic and HIV service data for female sex workers, men who have sex with men, and people who inject drugs in select West and Central African countries. *J Acquir Immune Defic Syndr* 2015; 68: S83–90. doi:10.1097/QAI.0000000000000457

3 UNAIDS. 90–90–90 - An ambitious treatment target to help end the AIDS epidemic; 2014. Available online at: http://www.unaids.org/en/resources/documents/2014/90-90-90 [verified 2 June 2016].

4 Ayala G, Makofane K, Santos G-M, Arreola S, Hebert P, Thomann M, *et al*. HIV treatment cascades that leak: correlates of drop-off from the HIV care continuum among men who have sex with men worldwide. *J AIDS Clin Res* 2014; 5: 331. doi:10.4172/2155-6113.1000331

5 Holland CE, Papworth E, Billong SC, Tamoufe U, LeBreton M, Kamla A, *et al*. Antiretroviral treatment coverage for men who have sex with men and female sex workers living with HIV in Cameroon. *J Acquir Immune Defic Syndr* 2015; 68(Suppl 2): S232–40. doi:10.1097/QAI.0000000000000443

6 Beyrer C, Baral SD, Weir BW, Curran JW, Chaisson RE, Sullivan PS. A call to action for concentrated HIV epidemics. *Curr Opin HIV AIDS* 2014; 9: 95–100. doi:10.1097/COH.0000000000000043

7 Beyrer C, Baral SD, van Griensven F, Goodreau SM, Chariyalertsak S, Wirtz AL, *et al*. Global epidemiology of HIV infection in men who have sex with men. *Lancet* 2012; 380: 367–77. doi:10.1016/S0140-6736(12)60821-6

8 Baral S, Sifakis F, Cleghorn F, Beyrer C. Elevated risk for HIV infection among men who have sex with men in low- and middle-income countries 2000–2006: a systematic review. *PLoS Med* 2007; 4: e339. doi:10.1371/journal.pmed.0040339

9 Centers for Disease Control and Prevention. HIV infections attributed to male-to-male sexual contact - metropolitan statistical areas, United States and Puerto Rico, 2010. *MMWR Morb Mortal Wkly Rep* 2012; 61: 962–6.

10 Beyrer C, Sullivan P, Sanchez J, Baral SD, Collins C, Wirtz AL, *et al*. The increase in global HIV epidemics in MSM. *AIDS* 2013; 27: 2665–78. doi:10.1097/01.aids.0000432449.30239.fe

11 Feng Y, Bu K, Li M, Zhang X, Jin S, Wang L. [Meta-analysis of HIV infection incidence and risk factors among men who have sex with men in China]. *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi* 2015; 36: 752–8. [in Chinese]

12 Zhang M, Chu Z, Wang H, Xu J, Lu C, Shang H. A rapidly increasing incidence of HIV and syphilis among men who have sex with men in a major city of China. *AIDS Res Hum Retroviruses* 2011; 27: 1139–40. doi:10.1089/aid.2010.0356

13 Peng Z, Yang H, Norris J, Chen X, Huan X, Yu R, *et al*. HIV incidence and predictors associated with retention in a cohort of men who have sex with men in Yangzhou, Jiangsu Province, China. *PLoS One* 2012; 7: e52731. doi:10.1371/journal.pone.0052731

14 Sanders EJ, Graham SM, Okuku HS, van der Elst EM, Muhaari A, Davies A, *et al*. HIV-1 infection in high risk men who have sex with men in Mombasa, Kenya. *AIDS* 2007; 21: 2513–20. doi:10.1097/QAD.0b013e3282f2704a

15 van Griensven F, Varangrat A, Wimonsate W, Tanpradech S, Kladsawad K, Chemnasiri T, *et al*. Trends in HIV prevalence, estimated HIV incidence, and risk behavior among men who have sex with men in Bangkok, Thailand, 2003–2007. *J Acquir Immune Defic Syndr* 2010; 53: 234–9. doi:10.1097/QAI.0b013e3181c2fc86

16 Price MA, Rida W, Mwangome M, Mutua G, Middelkoop K, Roux S, *et al*. Identifying at-risk populations in Kenya and South Africa: HIV incidence in cohorts of men who report sex with men, sex workers, and youth. *J Acquir Immune Defic Syndr* 2012; 59: 185–93. doi:10.1097/QAI.0b013e31823d8693

17 Phillips AN, Cambiano V, Nakagawa F, Brown AE, Lampe F, Rodger A, *et al*. Increased HIV incidence in men who have sex with men despite high levels of ART-induced viral suppression: analysis of an extensively documented epidemic. *PLoS One* 2013; 8: e55312. doi:10.1371/journal.pone.0055312

18 Beyrer C, Baral SD, Walker D, Wirtz AL, Johns B, Sifakis F. The expanding epidemics of HIV type 1 among men who have sex with men in low- and middle-income countries: diversity and consistency. *Epidemiol Rev* 2010; 32: 137–51. doi:10.1093/epirev/mxq011

19 Baral SD, Grosso A, Holland C, Papworth E. The epidemiology of HIV among men who have sex with men in countries with generalized HIV epidemics. *Curr Opin HIV AIDS* 2014; 9: 156–67. doi:10.1097/COH.0000000000000037

20 Sullivan PS, Jones JS, Baral SD. The global north: HIV epidemiology in high-income countries. *Curr Opin HIV AIDS* 2014; 9: 199–205. doi:10.1097/COH.0000000000000039

21 Lou J, Blevins M, Ruan Y, Vermund SH, Tang S, Webb GF, *et al*. Modeling the impact on HIV incidence of combination prevention strategies among men who have sex with men in Beijing, China. *PLoS One* 2014; 9: e90985. doi:10.1371/journal.pone.0090985

22 May RM, Anderson RM. Transmission dynamics of HIV infection. *Nature* 1987; 326: 137–42. doi:10.1038/326137a0

23 Winetrobe H, Rice E, Bauermeister J, Petering R, Holloway IW. Associations of unprotected anal intercourse with Grindr-met partners among Grindr-using young men who have sex with men in Los Angeles. *AIDS Care* 2014; 26: 1303–8. doi:10.1080/09540121.2014.911811

24 Beymer MR, Weiss RE, Bolan RK, Rudy ET, Bourque LB, Rodriguez JP, *et al*. Sex on demand: geosocial networking phone apps and risk of sexually transmitted infections among a cross-sectional sample of men who have sex with men in Los Angeles County. *Sex Transm Infect* 2014; 90: 567–72. doi:10.1136/sextrans-2013-051494

25 Stahlman S, Grosso A, Ketende S, Mothopeng T, Taruberekera N, Nkonyana J, *et al*. Characteristics of men who have sex with men in southern Africa who seek sex online: a cross-sectional study. *J Med Internet Res* 2015; 17: e129. doi:10.2196/jmir.4230

26 Ko NY, Tseng PC, Huang YC, Chen YC, Hsu ST. Seeking sex partners through the internet and mobile phone applications among men who have sex with men in Taiwan. *AIDS Care* 2016; 28: 927–31. doi:10.1080/09540121.2015.1131969

27 Bien CH, Best JM, Muessig KE, Wei C, Han L, Tucker JD. Gay apps for seeking sex partners in China: implications for MSM sexual health. *AIDS Behav* 2015; 19: 941–6. doi:10.1007/s10461-014-0994-6

28 Johnson AS, Hall HI, Hu X, Lansky A, Holtgrave DR, Mermin J. Trends in diagnoses of HIV infection in the United States, 2002–2011. *JAMA* 2014; 312: 432–4. doi:10.1001/jama.2014.8534

29 Centers for Disease Control and Prevention. HIV Incidence 2010. Available online at: http://www.cdc.gov/hiv/statistics/surveillance/incidence.html [verified 20 January 2016].

30 Rosenberg ES, Millett GA, Sullivan PS, Del Rio C, Curran JW. Understanding the HIV disparities between black and white men who have sex with men in the USA using the HIV care continuum: a modeling study. *Lancet HIV* 2014; 1: e112–8. doi:10.1016/S2352-3018(14)00011-3

31 Sullivan PS, Rosenberg ES, Sanchez TH, Kelley CF, Luisi N, Cooper HL, *et al*. Explaining racial disparities in HIV incidence in black and white men who have sex with men in Atlanta, GA: a prospective observational cohort study. *Ann Epidemiol* 2015; 25: 445–54. doi:10.1016/j.annepidem.2015.03.006

32 Millett GA, Peterson JL, Flores SA, Hart TA, Jeffries WL 4th, Wilson PA, *et al*. Comparisons of disparities and risks of HIV infection in black and other men who have sex with men in Canada, UK, and USA: a meta-analysis. *Lancet* 2012; 380: 341–8. doi:10.1016/S0140-6736(12)60899-X

33 Public Health Agency of Canada. HIV/AIDS epi updates: national HIV prevalence and incidence estimates for 2011 Centre for Communicable Diseases and Infection Control, Public Health Agency of Canada, 2014. Available online at: http://www.catie.ca/en/resources/hivaids-epi-update-chapter-1-national-hiv-prevalence-and-incidence-estimates-2011-0 [verified 2 June 2016].

34 The Kirby Institute. HIV, viral hepatitis and sexually transmissible infections in Australia: annual surveillance report. Sydney: The Kirby Institute, UNSW Australia. Available online at: http://kirby.unsw.edu.au/surveillance/2015-annual-surveillance-report-hiv-viral-hepatitis-stis [verified 2 June 2016].

35 Desai S, Croxford S, Brown AE, Mitchell H, Hughes G, Delpech V. An overview of the HIV epidemic among men who have sex with men in the United Kingdom, 1999–2013. *Euro Commun Dis Bull* 2015; 20: 1–10.

36 Castillo R, Konda KA, Leon SR, Silva-Santisteban A, Salazar X, Klausner JD, *et al*. HIV and sexually transmitted infection incidence and associated risk factors among high-risk MSM and male-to-female transgender women in Lima, Peru. *J Acquir Immune Defic Syndr* 2015; 69: 567–75. doi:10.1097/QAI.0000000000000667

37 Janiec J, Haar K, Spiteri G, Likatavicius G, Van de Laar M, Amato-Gauci AJ. Surveillance of human immunodeficiency virus suggests that younger men who have sex with men are at higher risk of infection, European Union, 2003 to 2012. *Euro Commun Dis Bull* 2013; 18: 20644. doi:10.2807/1560-7917.ES2013.18.48.20644

38 Wright NMJ, Tompkins CNE. Supervised injecting centres. *BMJ* 2004; 328: 100–2. doi:10.1136/bmj.328.7431.100

39 European Monitoring Centre for Drugs and Drug Addition. Drug consumption rooms: an overview of provision and evidence 2015. Available online at: http://www.emcdda.europa.eu/topics/pods/drug-consumption-rooms [verified 2 June 2016].

40 DeBeck K, Kerr T, Bird L, Zhang R, Marsh D, Tyndall M, *et al*. Injection drug use cessation and use of North America's first medically supervised safer injecting facility. *Drug Alcohol Depend* 2011; 113: 172–6. doi:10.1016/j.drugalcdep.2010.07.023

41 Baggaley RF, White RG, Boily MC. HIV transmission risk through anal intercourse: systematic review, meta-analysis and implications for HIV prevention. *Int J Epidemiol* 2010; 39: 1048–63. doi:10.1093/ije/dyq057

42 Glick SN, Morris M, Foxman B, Aral SO, Manhart LE, Holmes KK, *et al*. A comparison of sexual behavior patterns among men who have sex with men and heterosexual men and women. *J Acquir Immune Defic Syndr* 2012; 60: 83–90. doi:10.1097/QAI.0b013e318247925e

43 van Griensven F, Varangrat A, Wimonsate W, Tanpradech S, Kladsawad K, Chemnasiri T, *et al*. Trends in HIV prevalence, estimated HIV incidence, and risk behavior among men who have sex with men in Bangkok, Thailand, 2003–2007. *J Acquir Immune Defic Syndr* 2010; 53: 234–9. doi:10.1097/QAI.0b013e3181c2fc86

44 van Griensven F, Thienkrua W, McNicholl J, Wimonsate W, Chaikummao S, Chonwattana W, *et al*. Evidence of an explosive epidemic of HIV infection in a cohort of men who have sex with men in Thailand. *AIDS* 2013; 27: 825–32. doi:10.1097/QAD.0b013e32835c546e

45 Chariyalertsak S, Kosachunhanan N, Saokhieo P, Songsupa R, Wongthanee A, Chariyalertsak C, *et al*. HIV incidence, risk factors, and motivation for biomedical intervention among gay, bisexual men, and transgender persons in Northern Thailand. *PLoS One* 2011; 6: e24295. doi:10.1371/journal.pone.0024295

46 Zhang L, Chow EPF, Wilson DP. Distributions and trends in sexual behaviors and HIV incidence among men who have sex with men in China. *BMC Public Health* 2012; 12: 546. doi:10.1186/1471-2458-12-546

47 Garofalo R, Hotton AL, Kuhns LM, Gratzer B, Mustanski B. Incidence of HIV infection and sexually transmitted infections and related risk factors among very young men who have sex with men. *J Acquir Immune Defic Syndr* 2016; 72: 79–86. doi:10.1097/QAI.0000000000000933

48 Bedoya CA, Mimiaga MJ, Beauchamp G, Donnell D, Mayer KH, Safren SA. Predictors of HIV transmission risk behavior and

seroconversion among Latino men who have sex with men in Project EXPLORE. *AIDS Behav* 2012; 16: 608–17. doi:10.1007/s10461-011-9911-4

49 Mustanski BS, Newcomb ME, Bois SND, Garcia SC, Grov C. HIV in young men who have sex with men: a review of epidemiology, risk, and protector factors, and interventions. *J Sex Res* 2011; 48: 218–53. doi:10.1080/00224499.2011.558645

50 Sifakis F, Hylton JB, Flynn C, Solomon L, Mackellar DA, Valleroy LA, *et al*. Racial disparities in HIV incidence among young men who have sex with men: the Baltimore Young Men's Survey. *J Acquir Immune Defic Syndr* 2007; 46: 343–8. doi:10.1097/QAI.0b013e31815724cc

51 Prejean J, Tang T, Hall HI. HIV diagnoses and prevalence in the southern region of the United States, 2007–2010. *J Community Health* 2013; 38: 414–26. doi:10.1007/s10900-012-9633-1

52 Stall R, Duran L, Wisniewski SR, Friedman MS, Marshal MP, McFarland W, *et al*. Running in place: implications of HIV incidence estimates among urban men who have sex with men in the United States and other industrialized countries. *AIDS Behav* 2009; 13: 615–29. doi:10.1007/s10461-008-9509-7

53 Millett GA, Peterson JL, Wolitski RJ, Stall R. Greater risk for HIV infection of black men who have sex with men: a critical literature review. *Am J Public Health* 2006; 96: 1007–19. doi:10.2105/AJPH.2005.066720

54 Millett GA, Flores SA, Peterson JL, Bakeman R. Explaining disparities in HIV infection among black and white men who have sex with men: a meta-analysis of HIV risk behaviors. *AIDS* 2007; 21: 2083–91. doi:10.1097/QAD.0b013e3282e9a64b

55 Matthews DD, Herrick AL, Coulter RW, Friedman MR, Mills TC, Eaton LA, *et al*. Running backwards: consequences of current HIV incidence rates for the next generation of Black MSM in the United States. *AIDS Behav* 2016; 20: 7–16. doi:10.1007/s10461-015-1158-z

56 Hess K, Hu X, Lansky A, Mermin J, Hall HI. Estimating the lifetime risk of a diagnosis of HIV infection in the United States. Conference on Retroviruses and Opportunistic Infections (CROI); 23 February 2016; Boston, MA, USA; 2016.

57 Beyrer C. HIV epidemiology update and transmission factors: risks and risk contexts–16th International AIDS Conference epidemiology plenary. *Nephrol Dial Transplant* 2007; 44: 981–7.

58 Bourne A, Reid D, Hickson F, Rueda ST, Weatherburn P. The Chemsex Study: drug use in sexual settings among gay and bisexual men in Lambeth, Southwark & Lewisham 2014. Available online at: www.sigmaresearch.org.uk/chemsex [verified 2 June 2016].

59 Wu Z, Xu J, Liu E, Mao Y, Xiao Y, Sun X, *et al*. HIV and syphilis prevalence among men who have sex with men: a cross-sectional survey of 61 cities in China. *Nephrol Dial Transplant* 2013; 57: 298–309.

60 Liau A, Millett G, Marks G. Meta-analytic examination of online sex-seeking and sexual risk behavior among men who have sex with men. *Sex Transm Dis* 2006; 33: 576–84. doi:10.1097/01.olq.0000204710.35332.c5

61 Mayer KH, Bekker LG, Stall R, Grulich AE, Colfax G, Lama JR. Comprehensive clinical care for men who have sex with men: an integrated approach. *Lancet* 2012; 380: 378–87. doi:10.1016/S0140-6736(12)60835-6

62 Mayer KH, Venkatesh KK. Interactions of HIV, other sexually transmitted diseases, and genital tract inflammation facilitating local pathogen transmission and acquisition. *Am J Reprod Immunol* 2011; 65: 308–16. doi:10.1111/j.1600-0897.2010.00942.x

63 Kelley CF, Vaughan AS, Luisi N, Sanchez TH, Salazar LF, Frew PM, *et al*. The effect of high rates of bacterial sexually transmitted infections on HIV incidence in a cohort of Black and White men who have sex with men in Atlanta, Georgia. *AIDS Res Hum Retroviruses* 2015; 31: 587–92. doi:10.1089/aid.2015.0013

64 Smith AM, Grierson J, Wain D, Pitts M, Pattison P. Associations between the sexual behaviour of men who have sex with men and the structure and composition of their social networks. *Sex Transm Infect* 2004; 80: 455–8. doi:10.1136/sti.2004.010355

65 Johnson WD, Diaz RM, Flanders WD, Goodman M, Hill AN, Holtgrave D, *et al*. Behavioral interventions to reduce risk for sexual transmission of HIV among men who have sex with men. *Cochrane Database Syst Rev* 2008; 3CD001230. doi:10.1002/14651858.CD001230.pub2

66 Kelly JA, Amirkhanian YA, McAuliffe TL, Granskaya JV, Borodkina OI, Dyatlov RV, *et al*. HIV risk characteristics and prevention needs in a community sample of bisexual men in St. Petersburg, Russia. *AIDS Care* 2002; 14: 63–76. doi:10.1080/09540120220097946

67 Tieu HV, Li X, Donnell D, Vittinghoff E, Buchbinder S, Parente ZG, *et al*. Anal sex role segregation and versatility among men who have sex with men: EXPLORE Study. *J Acquir Immune Defic Syndr* 2013; 64: 121–5. doi:10.1097/QAI.0b013e318299cede

68 Mayer KH, Wheeler DP, Bekker LG, Grinsztejn B, Remien RH, Sandfort TG, *et al*. Overcoming biological, behavioral, and structural vulnerabilities: new directions in research to decrease HIV transmission in men who have sex with men. *J Acquir Immune Defic Syndr* 2013; 63: S161–7. doi:10.1097/QAI.0b013e318298700e

69 Goodreau SM, Peinado J, Goicochea P, Vergara J, Ojeda N, Casapia M, *et al*. Role versatility among men who have sex with men in urban Peru. *J Sex Res* 2007; 44: 233–9. doi:10.1080/00224490701443676

70 Hernández-Romieu AC, Sullivan PS, Rothenberg R, Grey J, Luisi N, Kelley CF, *et al*. Heterogeneity of HIV prevalence among the sexual networks of Black and White men who have sex with men in Atlanta: illuminating a mechanism for increased HIV risk for young Black men who have sex with men. *Sex Transm Dis* 2015; 42: 505–12. doi:10.1097/OLQ.0000000000000332

71 Valleroy LA, MacKellar DA, Karon JM, Rosen DH, McFarland W, Shehan DA, *et al*. HIV prevalence and associated risks in young men who have sex with men. Young Men's Survey Study Group. *JAMA* 2000; 284: 198–204. doi:10.1001/jama.284.2.198

72 Centers for Disease Control and Prevention Prevalence and awareness of HIV infection among men who have sex with men—21 Cities, United States, 2008. *MMWR Morb Mortal Wkly Rep* 2010; 59: 1201–7.

73 Blake SM, Ledsky R, Lehman T, Goodenow C, Sawyer R, Hack T. Preventing sexual risk behaviors among gay, lesbian, and bisexual adolescents: the benefits of gay-sensitive HIV instruction in schools. *Am J Public Health* 2001; 91: 940–6. doi:10.2105/AJPH.91.6.940

74 Centers for Disease Control and Prevention. HIV and young men who have sex with men. July 2014. Available online at: http://www.cdc.gov/healthyyouth/sexualbehaviors/pdf/hiv_factsheet_ymsm.pdf [verified 2 June 2016].

75 Mustanski B. Ethical and regulatory issues with conducting sexuality research with LGBT adolescents: a call to action for a scientifically informed approach. *Arch Sex Behav* 2011; 40: 673–86. doi:10.1007/s10508-011-9745-1

76 Idele P, Gillespie A, Porth T, Suzuki C, Mahy M, Kasedde S, *et al*. Epidemiology of HIV and AIDS among adolescents: current status, inequities, and data gaps. *J Acquir Immune Defic Syndr* 2014; 66: S144–53. doi:10.1097/QAI.0000000000000176

77 Baral SD, Ketende S, Mnisi Z, Mabuza X, Grosso A, Sithole B, *et al*. A cross-sectional assessment of the burden of HIV and associated individual- and structural-level characteristics among men who have sex with men in Swaziland. *J Int AIDS Soc* 2013; 16(Suppl 3): 18768. doi:10.7448/IAS.16.4.18768

78 Ayala G, Makofane K, Santos GM, Beck J, Do TD, Hebert P, *et al*. Access to basic HIV-related services and PrEP acceptability among men who have sex with men worldwide: barriers, facilitators, and implications for combination prevention. *J Sex Transm Dis* 2013. 1–11: doi:10.1155/2013/953123

79 Schwartz SR, Nowak RG, Orazulike I, Keshinro B, Ake J, Kennedy S, *et al*. The immediate effect of the Same-Sex Marriage Prohibition Act on stigma, discrimination, and engagement on HIV prevention and treatment services in men who have sex with men in Nigeria: analysis of prospective data from the TRUST cohort. *Lancet HIV* 2015; 2: e299–306. doi:10.1016/S2352-3018(15)00078-8

80 Risher K, Adams D, Sithole B, Ketende S, Kennedy C, Mnisi Z, *et al*. Sexual stigma and discrimination as barriers to seeking appropriate healthcare among men who have sex with men in Swaziland. *J Int AIDS Soc* 2013; 16(3, Suppl 2): 18715.

81 Pachankis JE, Hatzenbuehler ML, Hickson F, Weatherburn P, Berg RC, Marcus U, *et al*. Hidden from health: structural stigma, sexual orientation concealment, and HIV across 38 countries in the European MSM Internet Survey. *AIDS* 2015; 29: 1239–46. doi:10.1097/QAD.0000000000000724

82 Oldenburg CE, Perez-Brumer AG, Hatzenbuehler ML, Krakower D, Novak DS, Mimiaga MJ, *et al*. State-level structural sexual stigma and HIV prevention in a national online sample of HIV-uninfected MSM in the United States. *AIDS* 2015; 29: 837–45. doi:10.1097/QAD.0000000000000622

83 Chakrapani V, Newman PA, Shunmugam M, Dubrow R. Barriers to free antiretroviral treatment access among kothi-identified men who have sex with men and aravanis (transgender women) in Chennai, India. *AIDS Care* 2011; 23: 1687–94. doi:10.1080/09540121.2011.582076

84 Adebajo SB, Eluwa GI, Allman D, Myers T, Ahonsi BA. Prevalence of internalized homophobia and HIV associated risks among men who have sex with men in Nigeria. *Afr J Reprod Health* 2012; 16: 21–8.

85 Burnham KE, Cruess DG, Kalichman MO, Grebler T, Cherry C, Kalichman SC. Trauma symptoms, internalized stigma, social support, and sexual risk behavior among HIV-positive gay and bisexual MSM who have sought sex partners online. *AIDS Care* 2016; 28: 347–53. doi:10.1080/09540121.2015.1096894

86 Gamarel KE, Neilands TB, Dilworth SE, Taylor JM, Johnson MO. Smoking, internalized heterosexism, and HIV disease management among male couples. *AIDS Care* 2015; 27: 649–54. doi:10.1080/09540121.2014.991269

87 Pyun T, Santos GM, Arreola S, Do T, Hebert P, Beck J, *et al*. Internalized homophobia and reduced HIV testing among men who have sex with men in China. *Asia Pac J Public Health* 2014; 26: 118–25. doi:10.1177/1010539514524434

88 Ross MW, Kajubi P, Mandel JS, McFarland W, Raymond HF. Internalized homonegativity/homophobia is associated with HIV-risk behaviours among Ugandan gay and bisexual men. *Int J STD AIDS* 2013; 24: 409–13. doi:10.1177/0956462412472793

89 Berg RC, Ross MW, Weatherburn P, Schmidt AJ. Structural and environmental factors are associated with internalised homonegativity in men who have sex with men: findings from the European MSM Internet Survey (EMIS) in 38 countries. *Soc Sci Med* 2013; 78: 61–9. doi:10.1016/j.socscimed.2012.11.033

90 Fay H, Baral SD, Trapence G, Motimedi F, Umar E, Iipinge S, *et al*. Stigma, health care access, and HIV knowledge among men who have sex with men in Malawi, Namibia, and Botswana. *AIDS Behav* 2011; 15: 1088–97. doi:10.1007/s10461-010-9861-2

91 Mason K, Ketende S, Peitzmeier S, Ceesay N, Logie C, Diouf D, *et al*. Stigma, human rights violations, health care access, and disclosure among men who have sex with men in the Gambia. *J Human Rights Prac* 2015; 7: 139–52. doi:10.1093/jhuman/huu026

92 Stahlman S, Grosso A, Ketende S, Sweitzer S, Mothopeng T, Taruberekera N, *et al*. Depression and social stigma among MSM in Lesotho: implications for HIV and sexually transmitted infection prevention. *AIDS Behav* 2015; 19: 1460–9. doi:10.1007/s10461-015-1094-y

93 Zahn R, Grosso A, Scheibe A, Bekker LG, Ketende S, Dausab F, *et al*. Human rights violations among men who have sex with men in Southern Africa: comparisons between legal contexts. *PLoS One* 2016; 11: e0147156. doi:10.1371/journal.pone.0147156

94 Alvy LM, McKirnan DJ, Mansergh G, Koblin B, Colfax GN, Flores SA, *et al*. Depression is associated with sexual risk among men who have sex with men, but is mediated by cognitive escape and self-efficacy. *AIDS Behav* 2011; 15: 1171–9. doi:10.1007/s10461-010-9678-z

95 O'Cleirigh C, Newcomb ME, Mayer KH, Skeer M, Traeger L, Safren SA. Moderate levels of depression predict sexual transmission risk in HIV-infected MSM: a longitudinal analysis of data from six sites involved in a "prevention for positives" study. *AIDS Behav* 2013; 17: 1764–9. doi:10.1007/s10461-013-0462-8

96 Wei C, Cheung DH, Yan H, Li J, Shi LE, Raymond HF. The impact of homophobia and HIV stigma on HIV testing uptake among Chinese men who have sex with men: a mediation analysis. *J Acquir Immune Defic Syndr* 2016; 71: 87–93.

97 Supervie V, Ndawinz JDA, Lodi S, Costagliola D. The undiagnosed HIV epidemic in France and its implications for HIV screening strategies. *AIDS* 2014; 28: 1797–804. doi:10.1097/QAD.0000000000000270

98 Mannheimer SB, Wang L, Wilton L, Van Tieu H, Del Rio C, Buchbinder S, *et al*. Infrequent HIV testing and late HIV diagnosis are common among a cohort of black men who have sex with men in 6 US cities. *J Acquir Immune Defic Syndr* 2014; 67: 438–45. doi:10.1097/QAI.0000000000000334

99 Nelson KM, Thiede H, Jenkins RA, Carey JW, Hutcheson R, Golden MR. Personal and contextual factors related to delayed HIV diagnosis among men who have sex with men. *AIDS Educ Prev* 2014; 26: 122–33. doi:10.1521/aeap.2014.26.2.122

100 Dowson L, Kober C, Perry N, Fisher M, Richardson D. Why some MSM present late for HIV testing: a qualitative analysis. *AIDS Care* 2012; 24: 204–9.

101 Commission on AIDS in Asia. Redefining AIDS in Asia: crafting an effective response. New Delhi: Oxford University Press; 2008.

102 Golden MR, Bennett AB, Dombrowski JC, Buskin SE. Achieving the goals of the National HIV/AIDS strategy: declining HIV diagnoses, improving clinical outcomes, and diminishing racial/ethnic disparities in King County, WA (2004–2013). *Sex Transm Dis* 2016; 43: 269–76. doi:10.1097/OLQ.0000000000000434

103 Pettifor A, Nguyen NL, Celum C, Cowan FM, Go V, Hightow-Weidman L. Tailored combination prevention packages and PrEP for young key populations. *J Int AIDS Soc* 2015; 18(2, Suppl 1): 19434.

104 Coates TJ, Richter L, Caceres C. Behavioural strategies to reduce HIV transmission: how to make them work better. *Lancet* 2008; 372: 669–84. doi:10.1016/S0140-6736(08)60886-7

105 Grant RM, Lama JR, Anderson PL, McMahan V, Liu AY, Vargas L, *et al*. Preexposure chemoprophylaxis for HIV prevention in men who have sex with men. *N Engl J Med* 2010; 363: 2587–99. doi:10.1056/NEJMoa1011205

106 Molina JM, Capitant C, Spire B, Pialoux G, Cotte L, Charreau I, *et al*. On-demand preexposure prophylaxis in men at high risk for HIV-1 infection. *N Engl J Med* 2015; 373: 2237–46. doi:10.1056/NEJMoa1506273

107 McCormack S, Dunn DT, Desai M, Dolling DI, Gafos M, Gilson R, *et al*. Pre-exposure prophylaxis to prevent the acquisition of HIV-1

infection (PROUD): effectiveness results from the pilot phase of a pragmatic open-label randomised trial. *Lancet* 2016; 387: 53–60. doi:10.1016/S0140-6736(15)00056-2

108 Taddeo D, Egedy M, Frappier JY. Adherence to treatment in adolescents. *Paediatr Child Health* 2008; 13: 19–24.

109 Salema NE, Elliott RA, Glazebrook C. A systematic review of adherence-enhancing interventions in adolescents taking long-term medicines. *J Adolescent Health* 2011; 49: 455–66. doi:10.1016/j.jadohealth.2011.02.010

110 Marcus JL, Buisker T, Horvath T, Amico KR, Fuchs JD, Buchbinder SP, *et al*. Helping our patients take HIV pre-exposure prophylaxis (PrEP): a systematic review of adherence interventions. *HIV Med* 2014; 15: 385–95. doi:10.1111/hiv.12132

111 Hosek SG, Siberry G, Bell M, Lally M, Kapogiannis B, Green K, *et al*. The acceptability and feasibility of an HIV preexposure prophylaxis (PrEP) trial with young men who have sex with men. *J Acquir Immune Defic Syndr* 2013; 62: 447–56. doi:10.1097/QAI.0b013e3182801081

112 Spinner CD, Boesecke C, Zink A, Jessen H, Stellbrink HJ, Rockstroh JK, *et al*. HIV pre-exposure prophylaxis (PrEP): a review of current knowledge of oral systemic HIV PrEP in humans. *Infection* 2016; 44: 151–8. doi:10.1007/s15010-015-0850-2

113 Global Advocacy for HIV Prevention (AVAC). PrEPWatch: country updates. Available online at: http://www.prepwatch.org/advocacy/country-updates/ [verified 4 January 2016].

114 Authors. NHS England confirms decision not to fund drug that helps prevent HIV. 2016. Available online at: http://home.bt.com/news/uk-news/nhs-england-confirms-decision-not-to-fund-drug-that-helps-prevent-hiv-11364065437179 [verified 2 June 2016].

115 Boily MC, Shubber Z. Modelling in concentrated epidemics: informing epidemic trajectories and assessing prevention approaches. *Curr Opin HIV AIDS* 2014; 9: 134–49. doi:10.1097/COH.0000000000000036

116 Baral S, Scheibe A, Sullivan P, Trapence G, Lambert A, Bekker LG, *et al*. Assessing priorities for combination HIV prevention research for men who have sex with men (MSM) in Africa. *AIDS Behav* 2013; 17(Suppl 1): S60–9. doi:10.1007/s10461-012-0202-5

117 Mugo NR, Ngure K, Kiragu M, Irungu E, Kilonzo N. The preexposure prophylaxis revolution; from clinical trials to programmatic implementation. *Curr Opin HIV AIDS* 2016; 11: 80–6. doi:10.1097/COH.0000000000000224

118 Firestone R, Rivas J, Lungo S, Cabrera A, Ruether S, Wheeler J, *et al*. Effectiveness of a combination prevention strategy for HIV risk reduction with men who have sex with men in Central America: a mid-term evaluation. *BMC Public Health* 2014; 14: 1244. doi:10.1186/1471-2458-14-1244

119 Gomez GB, Borquez A, Caceres CF, Segura ER, Grant RM, Garnett GP, *et al*. The potential impact of pre-exposure prophylaxis for HIV prevention among men who have sex with men and transwomen in Lima, Peru: a mathematical modelling study. *PLoS Med* 2012; 9: e1001323. doi:10.1371/journal.pmed.1001323

120 Sood N, Wagner Z, Jaycocks A, Drabo E, Vardavas R. Test-and-treat in Los Angeles: a mathematical model of the effects of test-and-treat for the population of men who have sex with men in Los Angeles County. *Nephrol Dial Transplant* 2013; 56: 1789–96.

121 Jones A, Cremin I, Abdullah F, Idoko J, Cherutich P, Kilonzo N, *et al*. Transformation of HIV from pandemic to low-endemic levels: a public health approach to combination prevention. *Lancet* 2014; 384: 272–9. doi:10.1016/S0140-6736(13)62230-8

122 Makofane K, Beck J, Ayala G. MSM in Sub-Saharan Africa: health, access, and HIV. Findings from the Global Men's Health and Rights Study; 2012. Available online at: msmgf.org/files/msmgf/documents/MSMinSSA_PolicyBrief.pdf [verified 2 June 2016].

123 Public Health England UK standards for microbiology investigations: anti-HIV screening. *Virology* 2014; 11: 1–11.

124 Joint United Nations Programme on HIV/AIDS (UNAIDS). A short technical update on self-testing for HIV; 2014. Available online at: http://www.unaids.org/sites/default/files/media_asset/JC2603_self-testing_en_0.pdf [verified 10 February 2016].

125 United Nations International Children's Emergency Fund (UNICEF). Adolescents under the radar in the Asia-Pacific AIDS response. Bangkok, Thailand; 2015. Available online at: http://www.unicef.org/eapro/Adolescents_Under_the_Radar_final.pdf. [verified 5 July 2016].

126 Withey J. Sharp rise in HIV infections among young gay men in China; 2015. Available online at: https://www.gaytimes.co.uk/news/18829/sharp-rise-in-hiv-infections-among-young-gay-men-in-china/ [verified 19 January 2016].

127 Muessig KE, Nekkanti M, Bauermeister J, Bull S, Hightow-Weidman LB. A systematic review of recent smartphone, Internet and Web 2.0 interventions to address the HIV continuum of care. *Curr HIV/AIDS Rep* 2015; 12: 173–90. doi:10.1007/s11904-014-0239-3

128 Sullivan PS, Grey JA, Simon Rosser BR. Emerging technologies for HIV prevention for MSM: what we have learned, and ways forward. *J Acquir Immune Defic Syndr* 2013; 63(Suppl 1): S102–7. doi:10.1097/QAI.0b013e3182949e85

129 McGowan I, Cranston RD, Duffill K, Siegel A, Engstrom JC, Nikiforov A, *et al*. A phase 1 randomized, open label, rectal safety, acceptability, pharmacokinetic, and pharmacodynamic study of three formulations of Tenofovir 1% Gel (the CHARM-01 Study). *PLoS One* 2015; 10: e0125363. doi:10.1371/journal.pone.0125363

130 McGowan I. The development of rectal microbicides for HIV prevention. *Expert Opin Drug Deliv* 2014; 11: 69–82. doi:10.1517/17425247.2013.860132

131 Wang HB, Mo QH, Yang Z. HIV vaccine research: the challenge and the way forward. *J Immunol Res* 2015; 2015: 503978. doi:10.1155/2015/503978

132 Caskey M, Klein F, Lorenzi JC, Seaman MS, West AP Jr, Buckley N, *et al*. Viraemia suppressed in HIV-1-infected humans by broadly neutralizing antibody 3BNC117. *Nature* 2015; 522: 487–91. doi:10.1038/nature14411

133 Kong R, Louder MK, Wagh K, Bailer RT, deCamp A, Greene K, *et al*. Improving neutralization potency and breadth by combining broadly reactive HIV-1 antibodies targeting major neutralization epitopes. *J Virol* 2015; 89: 2659–71. doi:10.1128/JVI.03136-14

134 Ledgerwood JE, Coates EE, Yamshchikov G, Saunders JG, Holman L, Enama ME, *et al*. Safety, pharmacokinetics and neutralization of the broadly neutralizing HIV-1 human monoclonal antibody VRC01 in healthy adults. *Clin Exp Immunol* 2015; 182: 289–301. doi:10.1111/cei.12692

135 Baral S, Logie CH, Grosso A, Wirtz AL, Beyrer C. Modified social ecological model: a tool to guide the assessment of the risks and risk contexts of HIV epidemics. *BMC Public Health* 2013; 13: 482. doi:10.1186/1471-2458-13-482

136 Pando MA, Gómez-Carrillo M, Vignoles M, Rubio AE, dos Ramos Farias MS, Vila M, *et al*. Incidence of HIV type 1 infection, antiretroviral drug resistance, and molecular characterization in newly diagnosed individuals in Argentina: a global fund project. *AIDS Res Hum Retroviruses*. 2011; 27:17–23. doi:10.1089/aid.2010.0013

137 The Kirby Institute for Infection and Immunity in Society. Figure 46. HIV incidence rate per 100 person years in gay and bisexual men and female sex workers attending sexual health clinics, 2011–2014.

Available online at: https://kirby.unsw.edu.au/content/2015-asr-figures-data [verified 13 April 2016].

138 Silva AP, Greco M, Fausto MA, Greco DB, Carneiro M. Risk factors associated with HIV infection among male homosexuals and bisexuals followed in an open cohort study: Project Horizonte, Brazil (1994–2010). *PLoS One* 2014; 9: e109390. doi:10.1371/journal.pone.0109390

139 Li SW, Zhang XY, Li XX, Wang MJ, Li DL, Ruan YH, *et al*. Detection of recent HIV-1 infections among men who have sex with men in Beijing during 2005–2006. *Chin Med J (Engl)* 2008; 121: 1105–8.

140 Han M, Feng LG, Jiang Y, Shen S, Ling H, Ding XB, *et al*. Surveillance on HIV-1 incidence among men who have sex with men in Chongqing, China, 2006–2008. *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi* 2009; 30: 878–81.

141 Xu J, An M, Han X, Jia M, Ma Y, Zhang M, *et al*. Prospective cohort study of HIV incidence and molecular characteristics of HIV among men who have sex with men (MSM) in Yunnan Province, China. *BMC Infect Dis* 2013; 13: 3. doi:10.1186/1471-2334-13-3

142 Wang Q-Q, Chen X-S, Yin Y-P, Liang G-J, Zhang R-L, Jiang N, *et al*. HIV prevalence, incidence and risk behaviours among men who have sex with men in Yangzhou and Guangzhou, China: a cohort study. *J Int AIDS Soc* 2014; 17: 18849. doi:10.7448/IAS.17.1.18849

143 Mao H, Ma W, Lu H, Wang L, Zheng H, Zhu Y, *et al*. High incidence of HIV and syphilis among migrant men who have sex with men in Beijing, China: a prospective cohort study. *BMJ Open* 2014; 4: e005351. doi:10.1136/bmjopen-2014-005351

144 Wang Y, Huang Y, Chen H, Li L, Xu J, Li Z, *et al*. Incidence and correlates of HIV and syphilis in a prospective cohort of men who have sex with men in Mianyang, China, over a 36-month period. *Sex Health* 2015; 12: 546–555. doi:10.1071/SH14243

145 Liu G, Lu H, Wang J, Xia D, Sun Y, Mi G, *et al*. Incidence of HIV and syphilis among men who have sex with men (MSM) in Beijing: an open cohort study. *PLoS One* 2015; 10: e0138232. doi:10.1371/journal.pone.0138232

146 Li D, Yang X, Zhang Z, Wang Z, Qi X, Ruan Y, *et al*. Incidence of co-infections of HIV, herpes simplex virus type 2 and syphilis in a large cohort of men who have sex with men in Beijing, China. *PLoS One* 2016; 11: e0147422. doi:10.1371/journal.pone.0147422

147 Hui S, Li Y, Yan H, Guo W, Tong X, Wang K. HIV incidence and factor related to lost-to-follow-up among men who have sex with men in Harbin, Heilongjiang. *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi* 2015; 36: 1381–3.

148 Soto RJ, Ghee AE, Nunez CA, Mayorga R, Tapia KA, Astete SG, *et al*. Sentinel surveillance of sexually transmitted infections/HIV and risk behaviors in vulnerable populations in 5 Central American countries. *J Acquir Immune Defic Syndr* 2007; 46: 101–11.

149 Le Vu S, Velter A, Meyer L, Peytavin G, Guinard J, Pillonel J, *et al*. Biomarker-based HIV incidence in a community sample of men who have sex with men in Paris, France. *PLoS One* 2012; 7: e39872. doi:10.1371/journal.pone.0039872

150 Ghosh S, Mahapatra BB, Bania D. HIV incidence among men who sex with men: evidence from north-eastern part of India. 20th International AIDS Conference; Melbourne, Australia; 2014; Available online at: http://pag.aids2014.org/Abstracts.aspx?AID=6689 [verified 5 July 2016].

151 Giuliani M, Vescio MF, Latini A, Palamara G, Pimpinelli F, Dona MG, *et al*. Continuous increase in HIV-1 incidence after the year 2000 among men who have sex with men in Rome: insights from a 25-year retrospective cohort study. *Euro Commun Dis Bull* 2014; 19: 20969. doi:10.2807/1560-7917.ES2014.19.47.20969

152 Wahome E, Fegan G, Okuku HS, Mugo P, Price MA, Mwashigadi G, *et al*. Evaluation of an empiric risk screening score to identify acute and early HIV-1 infection among MSM in Coastal Kenya. *AIDS* 2013; 27: 2163–6. doi:10.1097/QAD.0b013e3283629095

153 Sanders EJ, Okuku HS, Smith AD, Mwangome M, Wahome E, Fegan G, *et al*. High HIV-1 incidence, correlates of HIV-1 acquisition, and high viral loads following seroconversion among MSM. *AIDS* 2013; 27: 437–46. doi:10.1097/QAD.0b013e32835b0f81

154 Jansen IA, Geskus RB, Davidovich U, Jurriaans S, Coutinho RA, Prins M, *et al*. Ongoing HIV-1 transmission among men who have sex with men in Amsterdam: a 25-year prospective cohort study. *AIDS* 2011; 25: 493–501. doi:10.1097/QAD.0b013e328342fbe9

155 Meireles P, Lucas R, Carvalho C, Fuertes R, Brito J, Campos MJ, *et al*. Incident risk factors as predictors of HIV seroconversion in the Lisbon cohort of men who have sex with men: first results, 2011–2014. *Euro Commun Dis Bull* 2015; 20: 1–12.

156 Dramé FM, Crawford EE, Diouf D, Beyrer C, Baral SD. A pilot cohort study to assess the feasibility of HIV prevention science research among men who have sex with men in Dakar, Senegal. *J Int AIDS Soc* 2013; 16(4, Suppl 3): 18753.

157 Ferrer L , Loureiro E, Meulbroek M, Folch C, Perez F, Esteve A, *et al*. High HIV incidence among men who have sex with men attending a community-based voluntary counselling and testing service in Barcelona, Spain: results from the ITACA cohort. *Sex Transm Infect* 2016; 92: 70–5. doi:10.1136/sextrans-2015-052042

158 Centers for Disease Control and Prevention. HIV and syphilis infection among men who have sex with men–Bangkok, Thailand, 2005–2011. *MMWR Morb Mortal Wkly Rep* 2013; 62: 518–20.

159 Brown EL, Wald A, Hughes JP, Morrow RA, Krantz E, Mayer K, *et al*. High risk of human immunodeficiency virus in men who have sex with men with herpes simplex virus type 2 in the EXPLORE study. *Am J Epidemiol* 2006; 164: 733–41. doi:10.1093/aje/kwj270

160 Balaji AB, Bowles KE, Le BC, Paz-Bailey G, Oster AM. High HIV incidence and prevalence and associated factors among young MSM, 2008. *AIDS* 2013; 27: 269–78. doi:10.1097/QAD.0b013e32835ad489

161 Koblin BA, Mayer KH, Eshleman SH, Wang L, Mannheimer S, del Rio C, *et al*. Correlates of HIV acquisition in a cohort of Black men who have sex with men in the United States: HIV prevention trials network (HPTN) 061. *PLoS One* 2013; 8: e70413. doi:10.1371/journal.pone.0070413

162 Pathela P, Braunstein SL, Blank S, Schillinger JA. HIV incidence among men with and those without sexually transmitted rectal infections: estimates from matching against an HIV case registry. *Nephrol Dial Transplant* 2013; 57: 1203–9.

163 Halkitis P, Kapadia F, Ompad D. Incidence of HIV infection in young gay, bisexual, and other YMSM: the P18 Cohort Study. *J Acquir Immune Defic Syndr* 2015; 69: 466–73. doi:10.1097/QAI.0000000000000616

164 Raymond HF, Chen YH, McFarland W. Estimating incidence of HIV infection among men who have sex with men, San Francisco, 2004–2014. *AIDS Behav* 2016; 20: 17–21. doi:10.1007/s10461-015-1223-7

165 Jain S, Oldenburg CE, Mimiaga MJ, Mayer KH. Subsequent HIV infection among men who have sex with men who used non-occupational post-exposure prophylaxis at a Boston community health center: 1997–2013. *AIDS Patient Care STDS* 2015; 29: 20–5. doi:10.1089/apc.2014.0154

166 Katz DA, Dombrowski JC, Bell TR, Kerani RP, Golden MR. HIV incidence among men who have sex with men after diagnosis with sexually transmitted infections. *Sex Transm Dis* 2016; 43: 249–54. doi:10.1097/OLQ.0000000000000423