HIV testing and engagement with the HIV treatment cascade among men who have sex with men in Africa: A systematic review and meta-analysis

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ABSTRACT

Background

HIV disproportionately affects gay, bisexual, and other men who have sex with men (MSM) in Africa, where many countries criminalise same-sex behaviour. We assessed changes in the engagement of African MSM with HIV testing and treatment cascade stages over time, and the influence of anti-LGBT legislation and stigma.

Methods

We systematically searched the peer-reviewed literature to October 10th, 2018 for studies and extracted or derived estimates of HIV testing and/or engagement with the HIV treatment cascade among African MSM from published reports. We derived pooled estimates using inverse-variance random-effects models. We used subgroup and meta-regression analysis to assess associations between testing and status awareness outcomes and study and participant characteristics including the severity of country-level anti-LGBT legislation.

Findings

Our searches identified 75 independent eligible studies that provided estimates for 44,993 MSM across one or more of five testing and treatment cascade outcomes. HIV testing increased significantly over time overall, with pooled overall proportions of MSM ever tested of 67·3% (95%Confidence interval 62·1-72·3%,N=44) and tested in the past 12 months of 50·1% (42·4-57·8%,N=31) post-2011 – 14% and 18% points higher than pre-2011, respectively. Post-2011, ever testing was highest in Southern(80·0%) and lowest in Northern(34·4%) and Central(56·1%) Africa, with the greatest increase in Western Africa(from 42·4 to 70·9%). Levels of both testing outcomes and status awareness were statistically significantly lower in countries with the most severe anti-LGBT legislation.

Few estimates were available for later stages of the treatment cascade. Available data post-2011 suggest that the pooled proportion of MSM HIV-positive aware has remained low (18·5%, 12·5-25·3%,N=28) whereas proportions of current ART use were 23·7% (15·5-33·0%,N=14) among all MSM living with HIV and 53·4% (36·9-69·5%,N=6) among MSM HIV-positive aware. Levels of viral suppression among MSM currently on ART were good (pooled: 75·6%, 64·4-85·5%,N=4), but low among all MSM living with HIV (pooled: 24·7%, 18·8-31·2%,N=4).

Interpretation

Available data suggests that levels of HIV status awareness among MSM living with HIV in Africa remain low, despite recent improvements in HIV testing; limited data is available on levels of engagement in care, ART use and viral suppression. We found that severe anti-LGBT legislation was associated with lower HIV testing and status awareness. Achieving UNAIDS 90-90-90 targets will require substantial improvements.

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INTRODUCTION

The development of highly active antiretroviral therapy (ART) in the 1990s transformed HIV from a fatal infection to a treatable chronic disease.[1] People living with HIV (PLHIV) on suppressive ART can live as long as people without HIV.[2] However, achieving viral suppression requires engagement in all stages of HIV care, from testing and early diagnosis, through the treatment cascade, including linkage into and retention in care, early ART initiation, and near-perfect adherence.[3] Globally, however, ~1 million PLHIV still die from HIV annually because they cannot or do not complete this cascade.[4,5]

UNAIDS has formulated the '90-90-90' targets, aiming to have 90% of PLHIV aware of their status, 90% of PLHIV aware of their status on ART, and 90% of PLHIV on ART achieving viral suppression by 2020,[6] with targets increasing to 95% by 2030.[7] Therefore, by 2020 and 2030, 73% and 86% of PLHIV should be virally suppressed, respectively.[7] Engaging PLHIV in the cascade to meet these ambitious targets will have major implications for PLHIV and HIV prevention, improving mortality and morbidity outcomes,[8] and reducing transmission risk.[9,10] UNAIDS has highlighted the importance of reaching key populations, including gay, bisexual, and other men who have sex with men (MSM), however estimates of progress towards achieving 90-90-90 targets among MSM are very scarce, which compromises our ability to assess impact, adequately address needs and reduce barriers to uptake of services, and improve HIV prevention services for MSM.[11,12] Globally, MSM are ~28 times more likely to be living with HIV than men in the general population – an inequality that is particularly apparent in sub-Saharan Africa, where the human rights of MSM are often violated.[5,13–19]

Almost two-thirds of African countries still criminalise same-sex relations, many with long prison sentences and some with the death penalty.[20] In this context, stigma, discrimination, and human rights violations of MSM that are linked to legislation have been widely documented.[5,13–19] This includes blackmail, violence, reprisals from family and communities, denial of housing, healthcare, and access to justice, and lack of adequate and accessible services for MSM.[21–23] These also create barriers to implementing effective HIV research, policy, and health programmes for MSM, through prohibition of activism and research, arbitrary arrests of healthcare providers, and disruption of services provided by community-based and non-governmental organisations (NGOs).[24–26] This may also explain why research on African MSM has lagged behind that in other parts of the world.[15,17,25–28]

After South Africa led the first United Nations (UN) resolution on sexual orientation and gender in 2011, some positive changes in lesbian, gay, bisexual and transgender (LGBT)

rights protection were reported in parts of Africa, albeit inconsistently.[29] For example, while Seychelles, São Tomé and Príncipe, Mozambique and Lesotho have decriminalised same-sex relations, Uganda and Nigeria have increased the severity of their anti-LGBT legislation.[20]

In this study, we (1) systematically reviewed published studies providing estimates of levels of HIV testing, diagnosis, and the treatment cascade among MSM in Africa; (2) assessed whether these outcomes have improved over time; and (3) explored the influence of participant and study characteristics, study quality, and two key structural factors – stigma and severity of anti-LGBT legislation – on each outcome.

METHODS

This systematic review and meta-analysis was reported in accordance with PRISMA and MOOSE guidelines.[30,31]

Search strategy and selection criteria

We searched Embase, Medline, Scopus, Global Health, and Web of Science for articles reporting on HIV testing and/or any HIV treatment cascade stages in Africa published between January 1st, 1980 and October 10th, 2018 using terms for HIV, MSM, and Africa (see appendix p 1 for full search terms).

We screened by abstract and title, then screened potentially relevant full-texts for studies directly reporting estimates or sufficient data to self-calculate proportions of MSM engaging in HIV testing and/or treatment cascade stages. We only included peer-reviewed cross-sectional or longitudinal studies recruiting at least 10 MSM. We excluded mathematical modelling studies, qualitative studies, conference abstracts and reviews, and studies reporting cascade outcomes using self-reported HIV status (instead of confirmed biological test) to derive the number of MSM living with HIV in the denominator. We did not exclude articles based on language.

For included studies, we extracted or self-calculated proportions of MSM: 1) who self-reported having ever or recently received an HIV test; 2) testing positive in the study ("MSM living with HIV" hereafter) who self-reported being HIV positive before testing ("MSM HIV+ aware" hereafter); 3) living with HIV who self-reported being ever or currently engaged in care or linked to care following diagnosis; 4) living with HIV or HIV+ aware who self-reported ever or currently taking ART; and 5) living with HIV, HIV+ aware, or currently on ART who were virally suppressed (based on viral load testing). We excluded estimates based on fewer than 10 MSM. One of four study authors contacted provided estimates of MSM ever and recently tested and of MSM living with HIV virally suppressed.[32]

For each study, we extracted information on participant characteristics (e.g. population, region of Africa, HIV prevalence among MSM participants tested in the study, proportion sold sex), stigma (e.g. proportion who disclosed their MSM status to healthcare workers or family, or were blackmailed), study characteristics and quality indicators (e.g. study year, study design, sampling and interview methods).

We used country-specific data from International Lesbian, Gay, Bisexual, Trans and Intersex Association (ILGA) reports, country constitutions, and UN reports to construct four

composite “anti-LGBT legislation” variables, one global anti-LGBT legislation index, and one “arrests” variable for each study country.[20,33–35]

The four anti-LGBT legislation variables are: repressive legislation (same-sex relations, sexual orientation-related NGOs, or LGBT promotion are illegal, age of consent differs for same-sex relationships, or legislation prohibits same-sex marriage and/or adoption; score 0-5), lack of protective legislation (LGBT people are not protected from discrimination, or incitement to hatred based on sexual orientation is not illegal; score 0-2), lack of progressive legislation (same-sex marriage and/or adoption are not legally recognised; score 0-2), and a penalties variable (the harshest punishment receivable for consensual same-sex relations varying from no punishment to the death penalty; score 0-5). Our global anti-LGBT legislation index summed the scores of these four legislation variables(score 0-14), for each study country at the time the study was conducted. Higher scores reflected less progressive legislation. The binary arrests variable captured if arrests for consensual same-sex relations had been documented in the country between 2014 and 2017 (the only such data available).[20] See appendix p 2-3 for additional details.

JS, ED, and RS independently performed all stages of screening and data extraction. Discrepancies were resolved by KM.

Data analysis

We pooled independent study estimates and calculated 95% confidence intervals (CI) and 95% prediction intervals (PrI) using random-effects models based on the DerSimonian-Laird inverse-variance method and the Freeman-Tukey transformation for proportions[36]. We provide estimates on the original scale. Heterogeneity across estimates was assessed using the I^2 statistic.[37,38] Where multiple articles estimated the same outcome for the same study population, we preferentially used estimates from the largest sample, or used the most recent estimates if sample sizes were equal. From these, we preferentially used weighted estimates accounting for clustering (e.g. from RDS studies) over crude estimates, where available (see appendix p 3-4 for details). For studies conducted in multiple locations, we preferentially extracted estimates for separate locations if reported; otherwise we used the combined estimate. For studies reporting on both MSM and transgender women (TGW), we included estimates for MSM alone if disaggregated data were available, otherwise we used estimates from the whole sample.

We assessed whether study estimates varied by study year, region, or other study, participant, or structural variables (e.g. population, MSM HIV prevalence, proportion sold

sex, stigma, anti-LGBT legislation (see appendix p 21-26 for full list)), and study quality using univariate meta-regression for study outcomes with ≥20 estimates. Additionally, we assessed whether time trends differed by region (using a model with region*study year (continuous) interaction) and country if there were ≥3 estimates at different time points. If study year was significantly ($p<0{\cdot}05$) associated with the outcome in univariate meta-regression, we also conducted bivariate (time-adjusted) meta-regression (adjusting for time as a continuous variable). We presented pooled estimates of outcomes stratified by variables statistically significantly associated in time-adjusted meta-regression in forest plots stratified by study year. We also conducted leave-one-out sensitivity analyses to explore how sensitive associations between ever testing and the global anti-LGBT legislation index were to the exclusion of individual countries and studies.

We further assessed study quality using subgroup analysis stratified by pre-defined quality indicators based on the AXIS tool for appraising cross-sectional studies,[39] including study design, reporting bias, publication bias, and a quality score summing the responses to three key quality criteria (see appendix p 5). We further assessed publication bias using funnel plots and Egger's test for asymmetry.[40]

We conducted all analyses with R 3.5.1 using the metafor package.[41,42]

Role of the funding source

The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

We included 113 articles reporting on 75 independent studies providing estimates (or data to self-calculate estimates) of the testing and cascade outcomes(Figure 1). The number of relevant studies conducted, and articles published, increased markedly from 2007 and 2010 onwards, respectively (see appendix p 6).

Table 1 summarises the outcomes, participant characteristics, structural variables, and study characteristics of included studies (see appendix p 7-15 for additional details).

Most studies provided proportions of MSM ever HIV tested(number of studies [N_s]=54, number of estimates [N_e]=81[32,43–95] recently tested (N_s=33, N_e=51)[32,43,46,48–51,62,73,76,78,80,82,85,96–109], and HIV+ aware (N_s=23, N_e=35).[32,43,48,51,58,62,68,87,88,110–122] Very few studies provided proportions of MSM engaged in care[68,116,118,123,124] on ART (ever[48,116,122,124], currently[32,68,102,116,118,119,125–128]), or virally suppressed [32,116,122,125,128–130] (Table 1a).

Over half the studies were conducted after 2011 (Table 1e). Studies provided estimates for 28 countries predominantly from Eastern,[32,43–61,77,97,108–111,121,122,124,125] Western,[88-92,94–97,99–106,108,115-117,129–134,139–141] and Southern[57,66–76,97,100–104,111–115,121,125,127] Africa (Table 1b, appendix p 19). Study participants were mainly recruited from the general population of MSM[32,43–45,47–51,53,56–59,62–70,72–84,86,88–96,98–101,103,104,106,107,109–120,122,123,127–130] (Table 1b). Various definitions of MSM were used for study inclusion, with the period of sexual activity with men varying between 3 months and lifetime and different types of sexual activity specified (e.g. anal sex only, anal or oral, anal/oral/masturbatory). HIV prevalence (1-69%) and the proportion ever/recently selling sex (11–82%) varied across studies. Face-to-face interviews were used approximately three times more frequently than confidential interview methods (e.g. audio computer-assisted self-interview). Most studies used respondent driven sampling (RDS; N_s=30; Table 1e). Sample sizes ranged from 26 to 2,453 participants.

Only 22 studies reported on stigma,[32,46,48,56,57,59,65,66,69,79,82–84,92,98,104,111,112,114,118,120,128–130] including proportions of MSM who disclosed their MSM status to healthcare workers, or family or had been blackmailed (Table 1c, appendix p 7-15). Most studies were conducted in countries where same-sex relations were illegal (N_s=55).[32,43–52,54–65,77–81,83,85–87,89–100,103,104,106,108–111,113,116,118–125,128–130] Forty-three studies were conducted in countries with documented arrests related to consensual same-sex relations in 2014-2017 (Table 1d).[32,43–45,47–49,51,52,54–61,63–65,77,78,80,81,87,90–94,96–100,103,108–111,113,116,118,120–122,124,125,128–130] Global anti-LGBT legislation scores ranged from 0 to 12 and were lower in countries where same-sex relations were legal than illegal (Table 1d, appendix p 16-18).

Study estimates, pooled estimates and 95% CI of all outcomes are summarised in Figures 2-8 and Table 2 and 95% PrI are presented in appendix p 20. Overall, the pooled proportion of MSM ever tested for HIV was 61·0% (95%CI 56·2–65·7%,N_e=81,I^2=98%), and was highest in Southern and lowest in Northern Africa (Figure 2, appendix p 21-22). The proportion of MSM tested in the past 12 months (pooled=46·2%,95%CI 39·6–52·9%,N_e=39,I^2=97%) was similar to the proportions tested in the past 6 and 3 months, and was highest in Southern and lowest in Eastern Africa (Figure 3, appendix p 23-24). The proportion of MSM HIV+ aware was much lower (pooled=18·2%,95%CI 13·0–23·9%,N_e=35,I^2=91%) especially in Eastern Africa (Figure 4, appendix p 25-26).

Overall, the pooled proportions of MSM living with HIV linked to care within 30 days of diagnosis, ever engaged or currently engaged in care, were low and varied between 15·3% and 40·4% (Figure 5). The overall pooled proportions of MSM living with HIV ever or currently on ART were below 24%, and between 37-53% among MSM HIV+ aware (Figures 6-7). Overall, an estimated 24·7%, 34·4%, and 75·6% of MSM living with HIV, MSM HIV+ aware, and MSM currently on ART were virally suppressed, respectively (Figure 8).

HIV testing ever (p=0·0025) and in the past 12 months (p=0·0015) increased continuously over time (Figures 2-3, appendix p 21-24), and by 14·8% and 17·9% percentage points, respectively, after 2011 compared with before (appendix p 27). Only time trends in ever tested differed between regions (year*region interaction: p<0·0001), with greater increases in Eastern and Western Africa, and significant within-county increases in Kenya, Uganda and Nigeria (Figure 2, appendix p 28-29). Testing in the past 12 months increased significantly over time in South Africa (appendix p 30). Post-2011, the proportions tested (ever or in the past 12 months) were highest in Southern and lowest in Northern and Eastern Africa, respectively (appendix p 27). The proportion of MSM HIV+ aware did not increase over time overall (p=0·38), or by region (year*region interaction: p=0·80)(Figure 4, appendix p 25-28), but increased in South Africa (appendix p 30). Too few estimates were available for the other cascade outcomes to assess time trends.

In time-adjusted meta-regression, higher proportions of MSM tested ever and in the past 12 months were associated with living in Southern Africa(p=0·0011; p=0·040) and less severe penalties for same-sex relations(p=0·0010; p=0·00024)(appendix p 21 and 23). Ever testing was also higher with more protective(p=0·0015) and progressive(p=0·016) legislation, no LGBT-related arrests from 2014-2017(p=0·020) and decreased by 2% (95%CI 1-4%) for each point increase on the global anti-LGBT legislation index(continuous; p=0·0026)(appendix p 21 and 31-32). The magnitude of the association was sensitive (approximately halved and no longer significant) to excluding all South African studies only,

but not to the exclusion of any single South African study (appendix p 31-32). Testing in the past 12 months was also higher with less repressive legislation (p=0·023) and with the lowest global anti-LGBT legislation index scores (categorical; p=0·010)(appendix p 23). In subgroup analysis, differences in testing ever and in the past 12 months by global anti-LGBT legislation score were reduced after 2011 (appendix p 33-35). In univariate meta-regression, a higher proportion of MSM HIV+ aware was associated with not living in Eastern Africa (p=0·046), less repressive legislation (p=0·014), less severe penalties for same-sex relations (p=0·00023), and a lower global anti-LGBT legislation index (categorical; p=0·0050)(appendix p 25).

Among the few studies reporting on stigma, testing ever and in the past 12 months were higher with greater disclosure of MSM status to healthcare workers in time-adjusted meta-regression (p<0·0001 and p=0.034, respectively)(appendix p 21-24). The proportion of MSM tested in the past 12 months (time-adjusted meta-regression: p=0·015) and HIV+ aware (univariate meta-regression: p=0·031) were higher with higher proportions of MSM being blackmailed (appendix p 23-26). Other outcomes had too few estimates to assess associations using meta-regression.

The influence of study quality was assessed for the three HIV testing and awareness outcomes with ≥20 study estimates (appendix p 36-42). Pooled estimates of all three outcomes differed with sampling method and were significantly higher in studies that did not use a complex study design or did not use statistical adjustment for complex study design (appendix p 21-26 and 40-42). Pooled estimates were also higher for studies specifically designed to estimate the outcome of interest (ever tested), with less adequate response rates (ever tested), that used more confidential interview methods (ever tested, tested in the past 12 months), that adequately described their methods and/or basic data (tested in the past 12 months), did not sufficiently describe their methods (MSM HIV+ aware) and with study populations not representative of wider MSM (MSM HIV+ aware). Although not statistically significant, higher rates of ever testing and HIV status awareness were observed for studies with a quality score of 0 (appendix p 40 and 42).

There was no evidence of publication bias for the proportions of MSM tested ever or in the past 12 months or HIV+ aware from funnel plots and Egger's asymmetry test (appendix p 43). Pooled proportions of MSM HIV+ aware were significantly higher for the subset of directly reported study estimates than those self-calculated (p=0·0045; appendix p 42).

DISCUSSION

Our results suggest that levels of engagement in HIV testing and particularly treatment cascade stages for African MSM remain sub-optimal, below those needed to achieve UNAIDS 90-90-90 targets.

From 2011 onwards, only 50% of MSM reported testing in the past 12 months, 19% were HIV+ aware, and 53% of MSM HIV+ aware were on ART. 76% of MSM on ART were virally suppressed, suggesting that once on ART, MSM can achieve fairly high viral suppression levels. However, since levels of diagnosis and ART access remain poor, levels of ART use (24%) and viral suppression (25%) among all MSM living with HIV are critically low, meaning HIV spread within these populations will continue.

We observed significant regional differences in HIV testing and status awareness. After 2011, levels of MSM ever tested, tested in the past 12 months and HIV+ aware were highest in Southern Africa and lowest in Northern, Eastern, and Eastern Africa, respectively. The greatest improvements in testing over time occurred in Eastern and Western Africa. These differences may reflect different levels of expansion of community-based testing and national HIV testing campaigns across regions.[131,132] Further expansion of community-led services, access to rapid and home-based testing, along with increased treatment support or counselling from LGBT-friendly organisations, will be essential to engage more MSM with HIV testing and treatment.[132]

We found evidence of statistically significant negative associations between testing and HIV status awareness and the severity of anti-LGBT legislation, which may, but do not necessarily, reflect causal relationships. These appeared to be mediated by negative associations between ever testing and a lack of protective or progressive legislation, or harsher penalties for same-sex relations, and between recently testing/HIV status awareness and repressive legislation or harsher penalties for same-sex relations. However, the strength of the association between our anti-LGBT legislation index and ever testing was influenced by South African estimates, which had the lowest anti-LGBT legislation scores. Thus, other country-level factors (e.g. healthcare- or epidemic-related) may partly confound this association.

Despite limited data availability, HIV testing and status awareness were lower in studies with lower disclosure of MSM status to healthcare workers, consistent with studies reporting associations between stigma and limited care cascade access.[56,133] Training for healthcare workers will be important to tackle the intersection of HIV-related stigma with discrimination

towards MSM and improve levels of testing and status awareness.[134] Consistent with other studies, we observed a positive association between ever testing and MSM HIV prevalence.[135] Higher prevalence could encourage MSM to test for HIV (as previous studies show that low threat perception can impede testing) or reflect targeting of testing services to more HIV-prevalent areas.[136]

Our pooled estimate of testing in the past 12 months pre-2011 (overall 33%) agreed with the 2008 UNGASS estimate of 30% among MSM in sub-Saharan Africa (from only one country however).[97] Available UNAIDS estimates of HIV status awareness among MSM in African countries – based on unpublished and/or more recent data – tended to be higher than our estimates, but UNAIDS ART coverage estimates for MSM living with HIV were mostly similar to ours.[12] Our results suggest a worse situation for MSM in Africa than elsewhere. Our cascade estimates for 2011 onwards are far below those from a study in six European and Central Asian countries, which reported that in 2016 83%, 70%, and 63% of MSM living with HIV were aware of their status, on ART, and virally suppressed,[137] respectively, compared with 19%, 24% and 25% from our study. A recent literature review showed higher levels of status awareness for high-income Western countries (72-100%) than we found, somewhat higher levels (44%) for India, another low-income setting, but similar levels (20%) for Russia, which enforces harsh anti-LGBT legislation.[25]

There are marked differences in HIV testing and ART coverage for African MSM compared with all men (see appendix p 44-46). Although levels of testing ever and in the past 12 months are consistently higher for MSM than all men across regions, self-reported HIV status awareness and ART coverage are substantially lower among MSM than corresponding estimates among men living with HIV (Mathieu Maheu-Giroux personal communication and appendix p 46).[138]

Our review has several strengths and limitations, partly due to data and study quality, which may reflect the challenges of conducting research among key populations that face substantial stigma.[133]

We reported new pooled estimates for 44,993 MSM across five outcomes from studies conducted between 2004 and 2017 and explored changes over time, by region and country. We self-calculated additional study estimates, increasing the sample size and minimising publication bias. We explored heterogeneity due to participant and study characteristics, additionally assessing the influence of anti-LGBT legislation using a novel index. ILGA publish the Rainbow Index for European countries[139], but to our knowledge no similar tools exist for African countries. Despite increases over time, studies on the treatment cascade

among MSM in Africa remain scarce, particularly for Central and Northern Africa. Studies were missing from 26 countries, 13 where same-sex relations are illegal. Therefore, our overall pooled estimates may not be representative of MSM across Africa and may misestimate engagement, especially for ART use and viral suppression, which were based on very few estimates. Small numbers of studies in Central and Northern Africa limit our ability to assess regional levels and trends in HIV testing.

Heterogeneity across study estimates was substantial and could only be explored in meta-regression for the outcomes with the most study estimates (ever testing, testing in past 12 months, HIV+ aware). Not all studies reported key participant characteristics including age, HIV prevalence and selling sex, with stigma the most poorly reported variable. Future studies should report on stigma alongside testing and treatment outcomes.

Our analysis included studies of generally moderate quality, and reporting biases were possible as most outcomes were self-reported, and most studies used non-confidential interview methods. Pooled estimates were influenced by study quality and in particular tended to be lower for studies that adjusted for complex study design (e.g. weighted RDS), with less confidential interview methods (testing outcomes) or with higher quality scores (albeit not significantly). Under-reporting has been previously documented among African MSM, for example in HPTN 075, 22% of MSM living with HIV self-reported a positive status, however ARVs were detected in 58%.[121] One study in Uganda found that approximately half of virally suppressed MSM (likely due to suppressive ART) reported not knowing their HIV-positive status.[32] Thus, our pooled estimates may underestimate true levels of status awareness and ART use. Obtaining representative samples of MSM is difficult, even with RDS sampling, with samples often biased towards younger, more visible MSM.[140] However, our pooled estimates did not differ by mean age. Many of the RDS studies included here did not report weighted estimates, potentially, but not necessarily, reducing their representativeness.[141]

Included studies used varied definitions of MSM and most did not disaggregate TGW from MSM, which however did not influence pooled study outcome estimates. However, it would be preferable in future to provide disaggregated estimates to gain a better understanding of the health needs of TGW. There was no evidence of publication bias for any outcome except status awareness, and only in subgroup analysis comparing directly reported and self-calculated estimates.

Our anti-LGBT legislation index only captures information about legislation, not how legislation is implemented. Only recent arrests after 2013 were available to measure

implementation, and for few African nations,[20] therefore we may not have fully captured the influence of changes in legislation implementation. More implementation data is needed. Nonetheless, our novel anti-LGBT legislation index reflected complex African legislation over time and enabled detailed analysis of our data in a legal context. Although no other measures or indexes are currently available specifically for Africa, our index correlates well with the recent global Homophobic Climate Index (data not shown).[142]

Engagement with the HIV treatment cascade among MSM in Africa remains low, despite recent improvements in HIV testing. Lower testing and status awareness levels were associated with more hostile legislation. More studies are needed on HIV testing and particularly the HIV treatment cascade for MSM across Africa, especially Northern and Central Africa. Future studies should use confidential interview methods to reduce reporting biases and collect standardised stigma data.

Contributions

MCB, JE, KM, ED and JS conceptualised this review and planned the analysis. JS, ED and RS conducted the search and independently performed all stages of screening. JS and ED independently extracted data, and JS conducted all analyses. KM double-checked data extraction and checked the data analysis, with input from MCB. JS, ED, KM and MCB interpreted the results and conceptualised the first draft of the review. JE and CB made significant intellectual contributions to the interpretation of the results and edited the manuscript. All authors read and approved the final version of the manuscript.

Declaration of interests

We declare no competing interests.

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TABLES

Table legends:

Table 1. Summary of (a) HIV testing and treatment cascade outcomes, (b) participant characteristics; (c) stigma variables; (d) anti-LGBT legislation variables of studies included in the analyses, and (e) study characteristics and quality indicators.

Table 2. Pooled estimates of the proportions of African MSM accessing HIV testing and different stages of the treatment cascade.

Table 1.

	Total unique studies* (N_s=75)	References
a. Testing and Treatment Cascade Outcomes		
HIV testing		
Ever	54	32,43–95
Recently tested	33	
Past 12 months	28	32,46,48–51,62,73,78,82,85,96–107
Past 6 months	8	43,46,76,78,80,101,106,108
Past 3 months	4	46,62,106,109
HIV+ Aware	23	
Self-reported	23	32,43,48,51,58,62,68,87,88,110–122
Engagement in Care	5	
Ever	2	116,118
Currently	2	123,124
Linked within 30 days of diagnosis	1	68
ART use	13	
MSM living with HIV	12	
Ever	4	48,116,122,124
Currently	9	32,68,102,116,118,119,125,126
MSM HIV+ aware	8	
Ever	3	48,116,122
Currently	6	32,68,116,119,127,128
Viral suppression	5	
MSM living with HIV	4	32,122,125,129
MSM HIV+ aware	3	32,122,128
MSM currently on ART	4	32,116,125,130
b. Participant Characteristics		
Population		
General MSM	60	32,43–45,47–51,53,56–59,62–70,72–84,86,88–96,98–101,103, 104,106,107,109–120,122,123,127–130
High-risk MSM†	9	52,54,55,71,102,103,121,124–126
Low-risk MSM‡	1	85
MSM organisations§	2	46,87
NR	3	61,97
Region of Africa¶		
Central	7	43,62–64,98,99,126
Eastern	27	32,43–61,77,97,108–111,121,122,124,125
Northern	2	65,10
Southern	19	57,66–76,98,101–104,111–115,121,125,127
Western	23	78–82,84–95,97,105–107,116–120,123,128–130
Mean or median age¶		
≤25	40	32,46–48,50,52,53,55–57,60,61,63,64,66,67,69,73,76–80,82, 83,85,86,88–91,93,96,97,99,100,103,107,108,110–114, 116–120,126
>25	37	44,45,49,51,54,57–59,65,68,70–73,75,81,84,87,92,94,95,98,101,102,104,105,109,111,115,119, 121–125,127–130
NR	4	43,62,97
HIV prevalence¶		
≤20%	26	32,43,48–51,54,56,57,62,66,68,74,78,79,82–84,88,90,93,100,101,103,107,111–113,115,117,119,120,122
>20%	22	45,47,48,51,52,57,58,63,66–68,70,81,85,87,90,94,99,101, 102,105,110–112,114,116,118,126,128–130
NR	33	44,46,53,55,59–61,64,65,69,71–73,75–77,80,86,89,91,92, 95–98,104,106,108,109,121,123–125,127
Proportion ever sold sex¶		
≤35%	9	53,57,59,60,68,69,101,104,108,111,114,127
>35%	9	32,44,49,56,57,74,80,87,92,109,111,115
NR	58	43,45–52,54,55,58,61–67,70–73,75–79,81–86,88–91,93–100, 102,103,105–107,110,112,113,116–126,128–130
Proportion sold sex recently¶‖		
≤41%	12	50,53,66,72,82,88,91,93,97,100,102,103,107,112,113,117,122
>41%	10	44,49,50,54,58,90–92,105,109

NR	55	32,43,45–48,51,52,55–57,59–65,67–71,73–81,83–87,89,94–99, 101,104,106,108,110,111,114–116,118–121,123–130
c. Stigma Variables		
Proportion disclosed MSM status to healthcare workers[¶]		
≤20%	6	57,66,82–84,111,112,114,117,119
>20%	8	32,48,56,57,81,98,104,111,118,128-130
NR	62	43–55,58–65,67–80,85–103,105–110,113,115,116,120–127
Proportion disclosed MSM status to family[¶]		
≤20%	4	32,57,66,82,111,112,117
>20%	12	48,57,65,69,79,81,92,98,103,104,111,113,118,128–130
NR	60	43–56,58–64,67,68,70–78,80,83–91,93–97,99–102,105–109, 110,114–116,119–127
Proportion blackmailed because MSM[¶]		
≤20%	6	46,57,59,81,82,111,117,118,120,128–130
>20%	7	57,66,83,98,103,104,111–113,119
NR	63	32,43–45,47–56,58,60–65,67–80,84–102,105–109,110, 114–116,119,121–127
d. Anti-LGBT Legislation		
Same-sex relations illegal[¶]		
Yes	55	32,43–52,54–65,77–81,83,85–87,89–100,103,104,106,108–111, 113,116,118–125,128–130
No	21	53,66–76,82,83,88,101,102,105,107,112,114,115,117,119,121, 125–127
Repressive[¶]		
0	13	66–74,101,102,112,114,115,121,125,126
1	13	75,76,82,84,88,90–93,97,104,105,107,117,119
2	35	43,44,50–52,54,55,57,58,60,62–64,79,83,85–87,89,91,93–99, 103,106,108,109,111,113,116,119–125
3 – 5	20	32,43,45–49,56,57,59,61,65,77,78,80,81,97,100,110–111,118, 121,125,128–130
Indeterminable	1	127
Lack of Protective[¶]		
0	14	67–76,101,102,114,115,121,125
1 – 2	62	32,43–52,54–66,77–100,103–113,116–126,127–130
Indeterminable	1	127
Lack of Progressive[¶]		
0	11	67–74,101,102,114,115,121,125
1 – 2	64	32,43–66,75–100,103–113,116–126,128–130
Indeterminable	1	127
Penalties[¶]		
0	23	53,57,66–76,82,84,88,101,102,104,105,107,111,112,114,115,117,119, 121,125,126
1	3	43,50,62
2	39	44,46,51,52,54,55,57,58,63–65,78–81,83,85–87,89–100,103, 106,109,111,113,116,118–125,128–130
3 – 5	17	32,43,45,47–49,56,57,59–61,77,91,93,97,108,110,111,121,125
Indeterminable	1	127
Arrests 2014-2017[¶]		
Yes	43	32,43–45,47–49,51,52,54–61,63–65,77,78,80,81,87,90–94, 96–100,103,108–111,113,116,118,120–122,124,125,128–130
No	35	43,46,50,53,57,62,66–76,79,82,83–86,88,89,95,97,101,102, 104–107,111,112,114,115,117,119,121,123,125–127
Global score[¶]		
≤5	21	53,66–76,82,84,88,101,102,104,105,107,112,114,115,117,119, 121,125,126
6 – 8	37	43,44,50–52,54,55,57,58,62–64,83,85–87,89–99,103,106,109, 111,113,116,119–125
≥9	23	32,43,45–49,56,57,59–61,65,77,78,80,81,91,93,97,100,108, 110–111,118,121,125,128–130
Indeterminable	1	127
e. Study Characteristics and Quality Indicators		
Study year		
Pre-2011	30	49,51–55,57–60,64,70–76,90–94,97,100,104,108,111,114, 115,124
2011 onwards	41	32,43–50,56,62,63,65–69,77–89,96,98,99,101–103,105–107, 109–110,112,113,116–123,125,128–130

NR	4	61,95,126,127
Study design[¶]		
Cross-sectional	64	32,43–51,53,55–57,59–77,79,80,82–86,88–100,102–117,119, 120,123,126,127
Cohort – baseline	10	52,54,58,78,81,87,101,118,121,122,124,125,128–130
NR	2	97
Sampling method		
RDS	30	32,45,47–51,56,60,62,63,66,68,72,74,79,81–85,88,90,91,93, 97–101,103,105,107,108,110,112,113,115,117–119,128–130
Cluster/time-venue	3	43,44,55,108
Snowball	18	53,57,59,64,67,77,78,86,89,94,96,98,104,106,111,120–122, 124,125
Purposive/convenience	17	46,54,58,65,69–71,73,75,80,92,95,102,114,123,126,127
Mix	3	52,76,116
NR	4	61,87,97
Interview method[¶]		
FTFI	54	43,45,48–55,57–60,62–64,66–68,72,74,76–79,81–85,88,89, 91–105,107,108,110–120,123,126,128–130
Confidential[**]	16	32,44,46,47,56,65,69– 71,73,75,80,86,106,109,110,121,122,125,127
ACASI/FTFI mix	2	90,124
NR	4	61,87,97

ACASI, audio computer-assisted self-interview software; ART, anti-retroviral therapy; FTFI, face-to-face interview; LGBT, lesbian, gay, bisexual and transgender; MSM, men who have sex with men; MSW, male sex workers; NR, not reported; PBS, polling booth survey; PWID, people who inject drugs; RDS, respondent-driven sampling; SAQ, self-administered questionnaire

Continuous variables were dichotomised at the median value.

* number of referenced articles differs from the number of studies when multiple articles report on the same study and provide different estimates for different testing and/or cascade outcomes or a single article reports on multiple studies
† high-risk MSM includes male sex workers, people who inject drugs, MSM recruited from drinking venues and STI clinics, and MSM identified as high-risk by study authors
‡ low-risk MSM includes non-PWID and MSM self-reported to be HIV-negative
§ MSM organisations includes MSM recruited from MSM/LGBT organisations/prevention activities
¶ same study included in more than one subcategory when a study reports multiple estimates across different levels of the variable
|| proportion sold sex recently includes MSM who have sold sex in the past 12, 6 or 3 months
** confidential interview methods include ACASI (N=5), pooling booth surveys (N=1), and self-administered questionnaires (N=10). All continuous variables dichotomised at the median

Table 2.

Cascade outcome	N_e	Pooled estimate (%)	95% CI	I^2
HIV testing (among all MSM)	132			
Ever	81	61·0	56·2 – 65·7	98%
Recently	51			
past 12 months	39	46·2	39·6 – 52·9	97%
past 6 months	8	38·8	26·0 – 52·4	96%
past 3 months	4	44·9	11·3 – 81·3	99%
HIV+ aware	35			
Among MSM living with HIV	35	18·2	13·0 – 23·9	91%
Engagement in Care (among MSM living with HIV)	6			
Ever*	2	33·7	0·0 – 92·5	99%
Current†	2	40·4	0·9 – 91·0	97%
Linked within 30 days of diagnosis	2	15·3	9·3 – 22·3	26%
ART use	29			
Among MSM living with HIV	20			
Ever	6	2·0	0·0 – 6.9	91%
Current	14	23·9	15·7 – 33·1	90%
Among MSM HIV+ aware	9			
Ever	3	37·3	0·0 – 90·3	94%
Current	6	53·4	36·9 – 69·5	86%
Viral suppression	11			
Among MSM living with HIV	4	24·7	18·8 – 31·2	50%
Among MSM HIV+ aware	3	34·4	28·3 – 40·7	0%
Among MSM currently on ART	4	75·6	64·4 – 85·5	45%

ART, antiretroviral therapy; CI, confidence interval; HIV, human immunodeficiency virus; MSM, men who have sex with men; N_e, number of estimates

HIV status of MSM living with HIV and MSM HIV+ aware was confirmed in the studies with an HIV test.

* includes ever received a CD4 test
† includes currently using cotrimoxazole and engaged in care at the start of the study

Figures Legends for Main Text

Figure 1. PRISMA flowchart
We included 113 articles reporting on 75 independent studies in the principal meta-analysis. (N_s=Number of studies, N_a=Number of articles). N_a can exceed N_s since more than one article can be published on the same study. One study estimating ART use only among "all MSM" was excluded. Abstracts of non-English articles were translated, where possible, and full-texts received and translated, if potentially relevant. We did not make exclusions based on language.

Figure 2. Forest plot of the proportions of African MSM ever tested
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa ever tested for HIV, overall and stratified by region of Africa. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). All testing history was self-reported. Estimates that were self-calculated are indicated by a *.

Figure 3. Forest plot of the proportions of African MSM recently tested in the past 12, 6, and 3 months
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa recently tested for HIV in the past 12 months (black), 6 months (red), and 3 months (blue), overall and stratified by region of Africa. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). All testing history was self-reported. Estimates that were self-calculated are indicated by a *.

Figure 4. Forest plot of the proportions of African MSM HIV+ aware
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa HIV+ aware, overall and stratified by region of Africa. MSM HIV+ aware are those who reported living with HIV before testing positive during the study. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). Estimates that were self-calculated are indicated by a *.

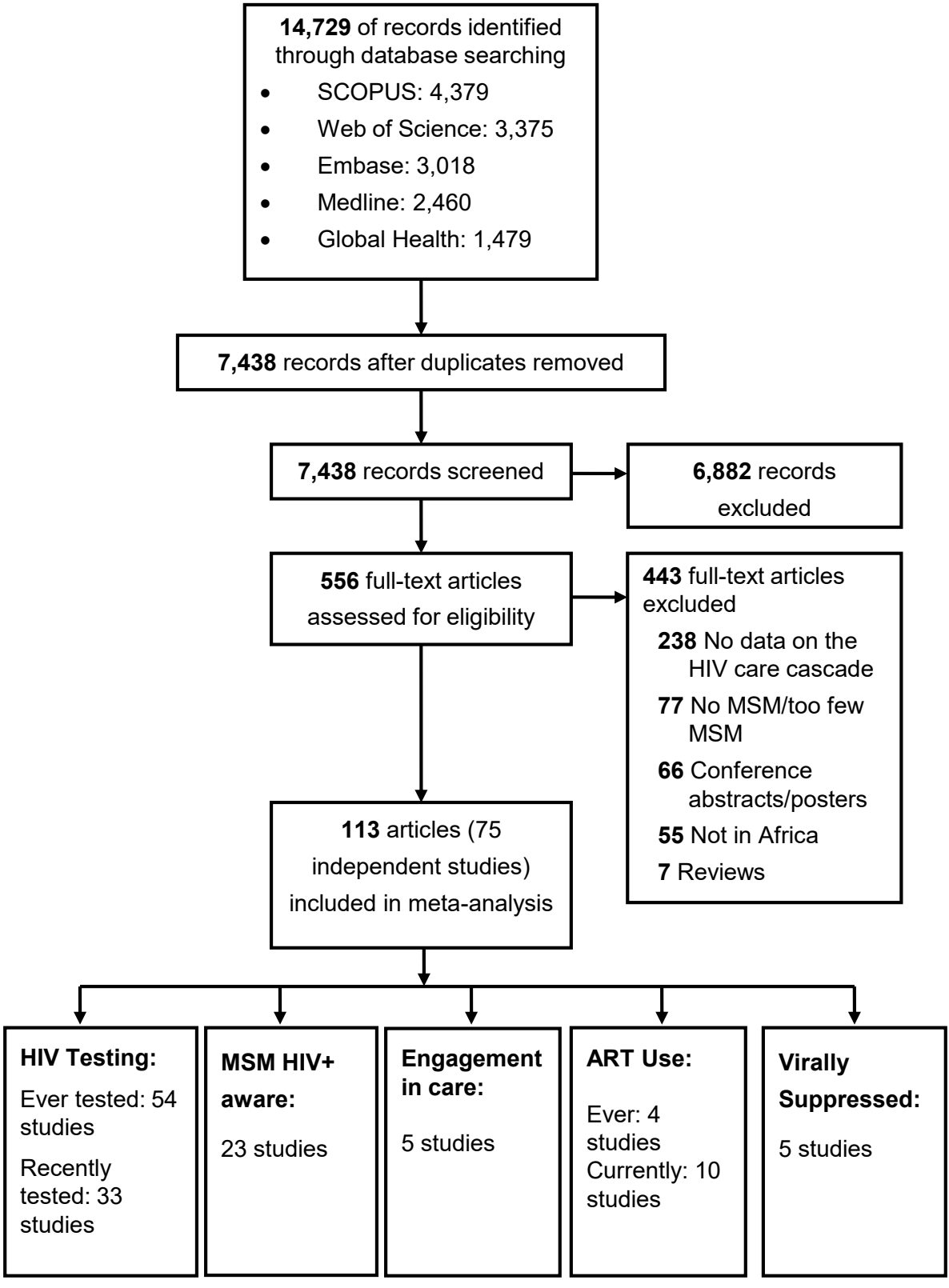
Figure 5. Forest plot of the proportions of African MSM living with HIV ever or currently engaged in care, or linked to care within 30 days of diagnosis
Study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa living with HIV ever or currently engaged in care, or linked to care within 30 days of diagnosis, overall and stratified by region of Africa. All study estimates were unweighted. All engagement in care was self-reported. MSM living with HIV are those who tested positive during the study. Numerators and denominators of weighted study estimates are rounded to the nearest whole number. Estimates that were self-calculated are indicated by a *.

Figure 6. Forest plot of the proportions of African MSM living with HIV ever or currently on ART
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa living with HIV ever or currently on ART, overall and stratified by region of Africa. All ART use was self-reported. MSM living with HIV are those who tested positive during the study. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). Estimates that were self-calculated are indicated by a *.

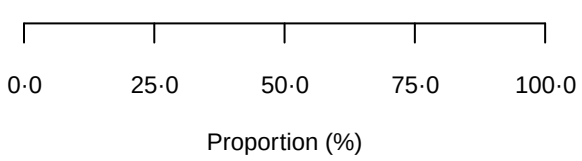
Figure 7. Forest plot of the proportions of African MSM HIV+ aware ever or currently on ART
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa HIV+ aware ever or currently on ART, overall and stratified by region of Africa. All ART use was self-reported. MSM HIV+ aware are those who reported living with HIV before testing positive during the study. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). Estimates that were self-calculated are indicated by a *.

Figure 8. Forest plot of the proportions of African MSM living with HIV, HIV+ aware, and currently on ART that were virally suppressed

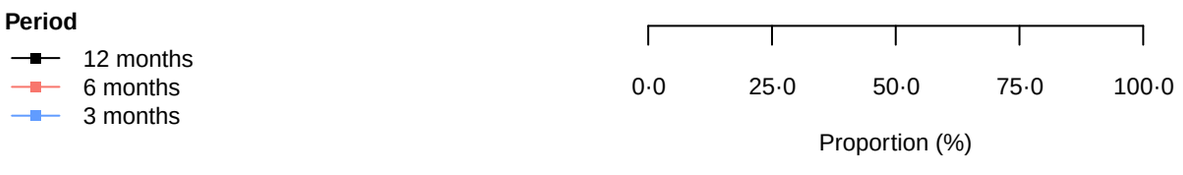
Weighted (blank squares) and unweighted (filled squares) study estimates and their 95% CIs and pooled estimates (diamonds) and their 95% CIs are shown for proportions of MSM in Africa living with HIV, HIV+ aware, and currently on ART that were virally suppressed, overall and stratified by region of Africa. All ART use was self-reported. MSM living with HIV are those who tested positive during the study. MSM HIV+ aware are those who reported living with HIV before testing positive during the study. Numerators and denominators of weighted study estimates were derived from the effective sample size (see appendix p 3-4). Viral suppression was measured within studies with viral load testing using thresholds defined by the study authors. Estimates that were self-calculated are indicated by a *.

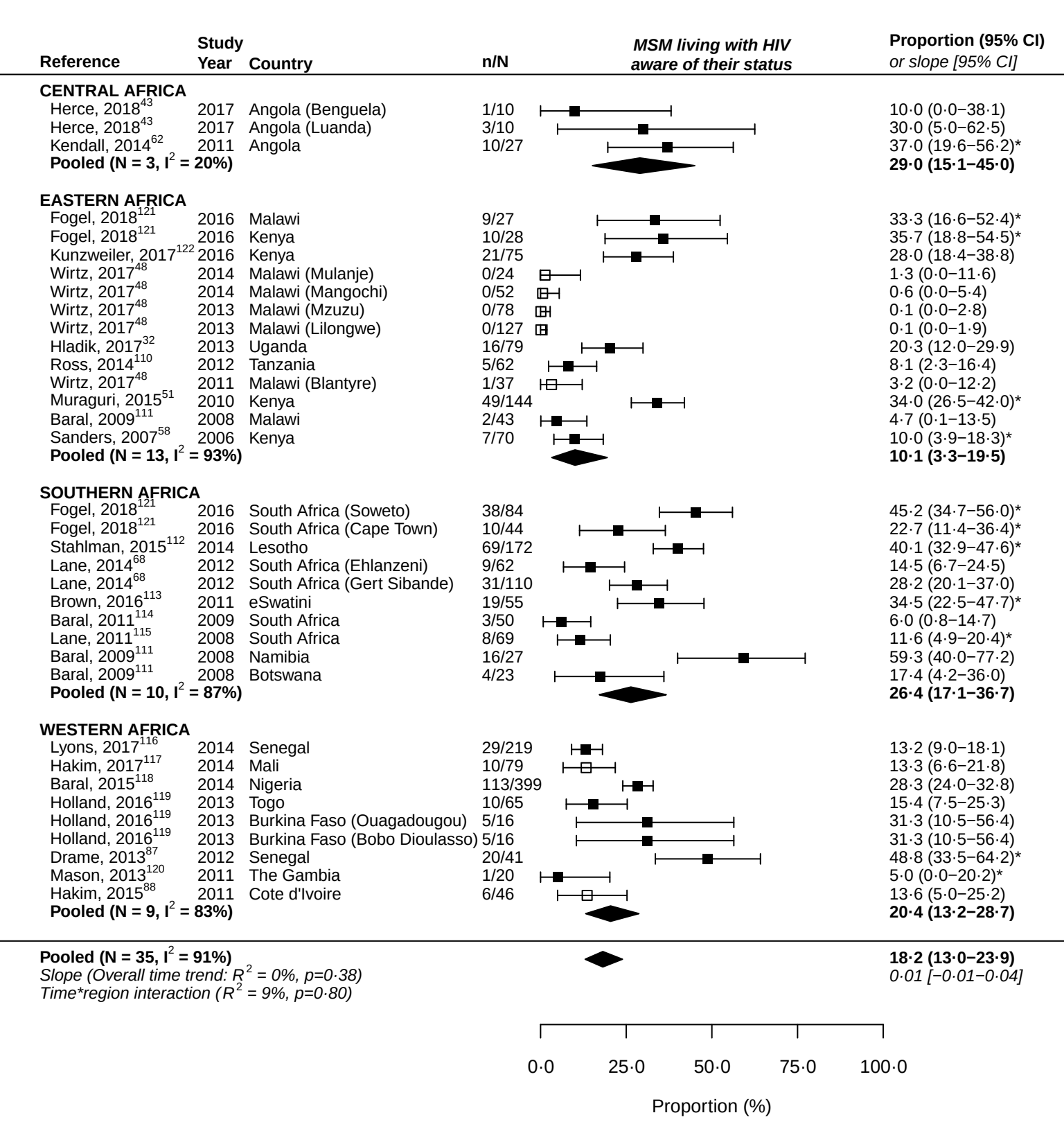

14,729 of records identified through database searching
SCOPUS: 4,379
Web of Science: 3,375
Embase: 3,018
Medline: 2,460
Global Health: 1,479
7,438 records after duplicates removed
7,438 records screened
6,882 records excluded
556 full-text articles assessed for eligibility
443 full-text articles excluded
238 No data on the HIV care cascade
77 No MSM/too few MSM
66 Conference abstracts/posters
55 Not in Africa
7 Reviews
113 articles (75 independent studies) included in meta-analysis
HIV Testing:
Ever tested: 54 studies
Recently tested: 33 studies
MSM HIV+ aware:
23 studies
Engagement in care:
5 studies
ART Use:
Ever: 4 studies
Currently: 10 studies
Virally Suppressed:
5 studies

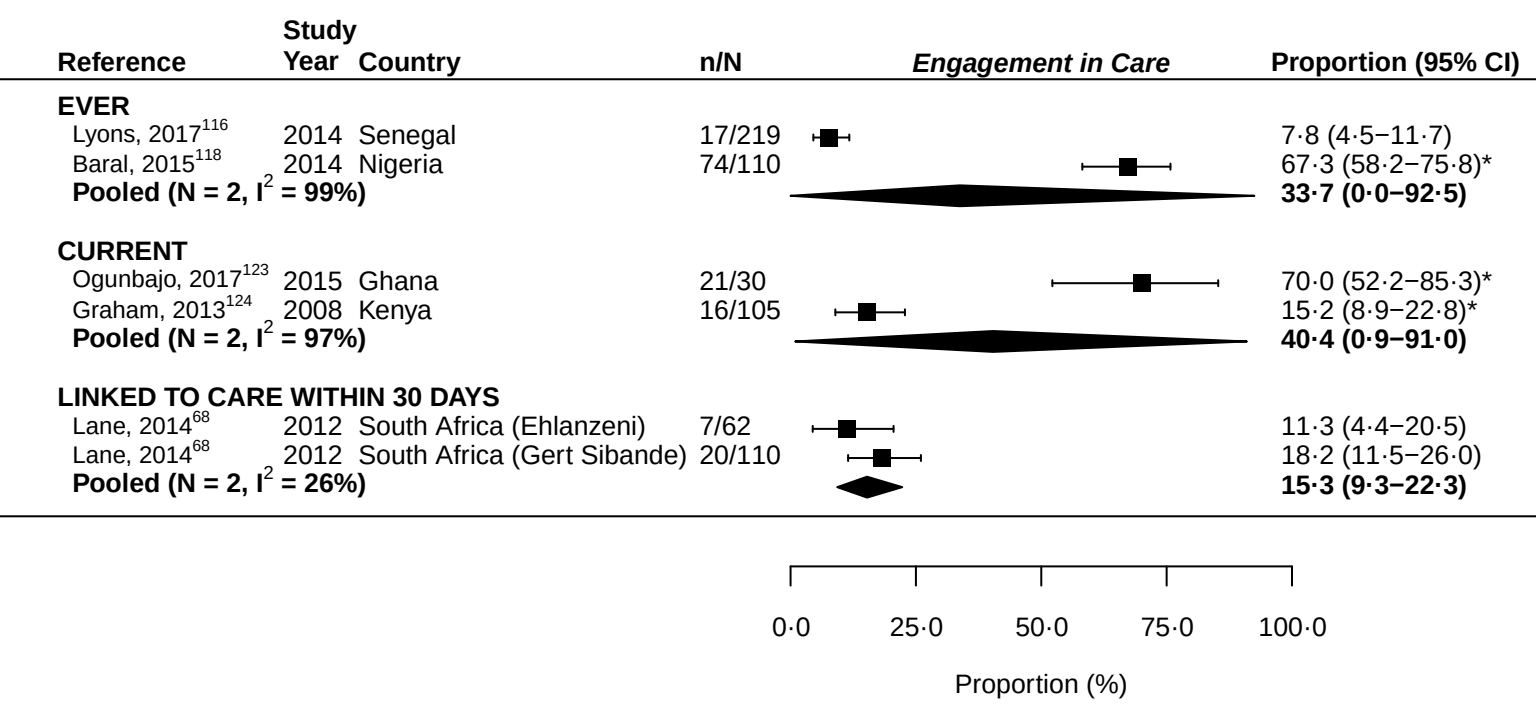
Reference	Study Year	Country	n/N	*Ever Tested*	Proportion (95% CI) *or slope [95% CI]*
CENTRAL AFRICA					
Herce, 2018[43]	2017	Angola	92/256		35·9 (30·2–41·9)
Herce, 2018[43]	2017	Angola	215/457		47·0 (42·5–51·6)
Kendall, 2014[62]	2011	Angola	125/328		38·1 (32·9–43·4)
Holland, 2015[63]	2011	Cameroon	127/159		79·7 (73·1–85·6)
Holland, 2015[63]	2011	Cameroon	123/159		77·5 (70·6–83·7)
Lorente, 2012[64]	2008	Cameroon	134/165		81·2 (74·9–86·8)
Pooled (N = 6, I^2 = 98%)					**60·7 (43·5–76·6)**
Slope (Regional time trend: R^2 = 21%, p=0·056)					*−0·04 [−0·09–0·00]*
EASTERN AFRICA					
Herce, 2018[43]	2017	Malawi	86/115		74·8 (66·4–82·3)
Musyoki, 2018[44]	2014	Kenya	1201/1308		91·8 (90·3–93·2)
Mmbaga, 2018[45]	2014	Tanzania	472/753		62·7 (59·2–66·1)
Wirtz, 2017[48]	2014	Malawi	33/56		59·4 (46·2–72·0)
Wirtz, 2017[48]	2014	Malawi	18/44		41·0 (26·8–56·0)
Wirtz, 2017[48]	2014	Malawi	25/48		51·6 (37·4–65·7)
Wirtz, 2017[48]	2014	Malawi	9/32		27·9 (13·6–44·8)
Coulaud, 2016[46]	2014	Burundi	49/51		96·1 (88·5–99·9)*
Wirtz, 2017[48]	2013	Malawi	5/11		43·3 (14·6–74·3)
Wirtz, 2017[48]	2013	Malawi	7/14		46·9 (21·2–73·4)
Wanyenze, 2016[77]	2013	Uganda	76/85		89·4 (81·9–95·2)
Hladik, 2017[32]	2013	Uganda	163/251		65·1 (59·1–70·9)
Romijnders, 2016[47]	2012	Tanzania	230/296		77·7 (72·8–82·3)
Wirtz, 2017[48]	2011	Malawi	11/22		48·3 (27·7–69·2)
Khatib, 2017[49]	2011	Tanzania	132/194		68·2 (61·5–74·6)
Horth, 2015[50]	2011	Mozambique	186/347		53·6 (48·3–58·8)
Horth, 2015[50]	2011	Mozambique	377/572		65·9 (62·0–69·7)
Horth, 2015[50]	2011	Mozambique	286/493		58·0 (53·6–62·3)
Muraguri, 2015[51]	2010	Kenya	402/563		71·4 (67·6–75·1)*
McKinnon, 2013[52]	2010	Kenya	435/507		85·8 (82·6–88·7)
Chapman, 2011[53]	2009	Rwanda	55/88		62·5 (52·1–72·4)*
Moller, 2015[54]	2008	Kenya	266/561		47·4 (43·3–51·6)
Luchters, 2011[55]	2008	Kenya	283/442		64·0 (59·5–68·4)*
Hladik, 2012[56]	2008	Uganda	66/153		43·4 (35·6–51·3)
Fay, 2011[57]	2008	Malawi	69/196		35·2 (28·7–42·0)
Khatib, 2017[49]	2007	Tanzania	71/376		18·8 (15·0–22·9)
Sanders, 2007[58]	2006	Kenya	72/285		25·3 (20·4–30·5)
Ntata, 2008[59]	2006	Malawi	57/97		58·8 (48·8–68·4)
Kajubi, 2008[60]	2004	Uganda	19/78		24·0 (15·1–34·2)
Nyoni, 2012[61]	NR	Tanzania	164/271		60·5 (54·6–66·3)
Pooled (N = 30, I^2 = 98%)					**58·6 (50·1–67·0)**
Slope (Regional time trend: R^2 = 43%, p=0·0010)					*0·04 [0·01–0·06]*
NORTHERN AFRICA					
Elmahy, 2018[65]	2016	Egypt	159/461		34·5 (30·2–38·9)
SOUTHERN AFRICA					
Stahlman, 2015[66]	2014	Lesotho	366/530		69·1 (65·1–72·9)*
Siegler, 2015[67]	2012	South Africa	33/34		97·1 (87·8–100·0)*
Lane, 2014[68]	2012	South Africa	102/147		69·3 (61·6–76·5)
Lane, 2014[68]	2012	South Africa	98/150		65·8 (58·0–73·2)
Batist, 2013[69]	2012	South Africa	91/97		93·8 (88·0–97·9)
Wagenaar, 2012[70]	2010	South Africa	382/439		87·0 (83·7–90·0)
Eaton, 2013[71]	2010	South Africa	89/142		62·7 (54·5–70·5)
Tun, 2012[72]	2009	South Africa	86/120		71·1 (62·6–78·9)
Knox, 2011[73]	2008	South Africa	203/300		67·7 (62·3–72·9)
Fay, 2011[57]	2008	Namibia	129/217		59·4 (52·8–65·9)
Fay, 2011[57]	2008	Botswana	97/117		82·9 (75·5–89·2)
Arnold, 2013[74]	2008	South Africa	158/377		41·9 (37·0–46·9)
Sandfort, 2008[75]	2004	South Africa	728/1045		69·7 (66·8–72·4)
Lane, 2008[76]	2004	South Africa	99/147		67·3 (59·5–74·7)*
Pooled (N = 14, I^2 = 95%)					**72·6 (65·3–79·3)**
Slope (Regional time trend: R^2 = 0%, p=0·23)					*0·02 [−0·01–0·05]*
WESTERN AFRICA					
Tun, 2018[78]	2017	Nigeria	262/319		82·1 (77·7–86·2)
Teclessou, 2017[79]	2015	Togo	317/466		68·0 (63·7–72·2)*
Tobin−West, 2017[80]	2014	Nigeria	70/101		69·3 (59·9–78·0)
Rodriguez−Hart, 2018[81]	2014	Nigeria	1017/1479		68·8 (66·4–71·1)
Lahuerta, 2018[82]	2014	Mali	169/236		71·6 (65·7–77·2)*
Ruisenor−Escudero, 2017[83]	2013	Togo	57/91		62·1 (51·9–71·8)
Goodman, 2016[84]	2013	Burkina Faso	506/670		75·5 (72·2–78·7)*
Girault, 2015[85]	2013	Ghana	56/114		49·1 (40·0–58·3)
Girault, 2015[85]	2013	Ghana	44/52		84·6 (73·4–93·3)
Kushwaha, 2017[86]	2012	Ghana	29/33		87·9 (74·2–97·2)
Kushwaha, 2017[86]	2012	Ghana	17/51		33·3 (21·0–46·9)
Kushwaha, 2017[86]	2012	Ghana	47/53		88·7 (78·5–96·0)
Drame, 2013[87]	2012	Senegal	103/117		88·0 (81·5–93·4)
Hakim, 2015[88]	2011	Cote d'Ivoire	165/263		62·6 (56·7–68·4)
Bakai, 2016[89]	2011	Togo	446/708		63·0 (59·4–66·5)*
Vu, 2013[90]	2010	Nigeria	57/149		38·3 (30·6–46·3)
Vu, 2013[90]	2010	Nigeria	35/111		31·8 (23·4–40·8)
Vu, 2013[90]	2010	Nigeria	39/70		55·8 (44·0–67·3)
Eluwa, 2015[91]	2010	Nigeria	31/67		46·3 (34·5–58·3)
Eluwa, 2015[91]	2010	Nigeria	35/59		59·5 (46·7–71·7)
Eluwa, 2015[91]	2010	Nigeria	51/73		70·9 (59·9–80·8)
Eluwa, 2015[91]	2010	Nigeria	29/49		58·7 (44·6–72·2)
Eluwa, 2015[91]	2010	Nigeria	18/39		47·3 (31·7–63·2)
Eluwa, 2015[91]	2010	Nigeria	63/167		37·9 (30·7–45·4)
Stromdahl, 2012[92]	2008	Nigeria	180/276		65·2 (59·5–70·7)
Merrigan, 2011[93]	2007	Nigeria	69/258		26·7 (21·5–32·3)
Merrigan, 2011[93]	2007	Nigeria	38/215		17·7 (12·9–23·1)
Merrigan, 2011[93]	2007	Nigeria	85/207		40·9 (34·3–47·7)
Wade, 2005[94]	2004	Senegal	50/463		10·8 (8·1–13·8)
Lieber, 2018[95]	NR	Liberia	83/107		77·6 (69·1–85·0)
Pooled (N = 30, I^2 = 98%)					**58·3 (50·0–66·5)**
Slope (Regional time trend: R^2 = 71%, p<0·0001)					*0·06 [0·04–0·08]*
Pooled (N = 81, I^2 = 98%)					**61·0 (56·2–65·7)**
Slope (Overall time trend: R^2 = 10%, p=0·0025)					*0·02 [0·01–0·04]*
*Time*region interaction (R^2 = 42%, p<0·0001)*					

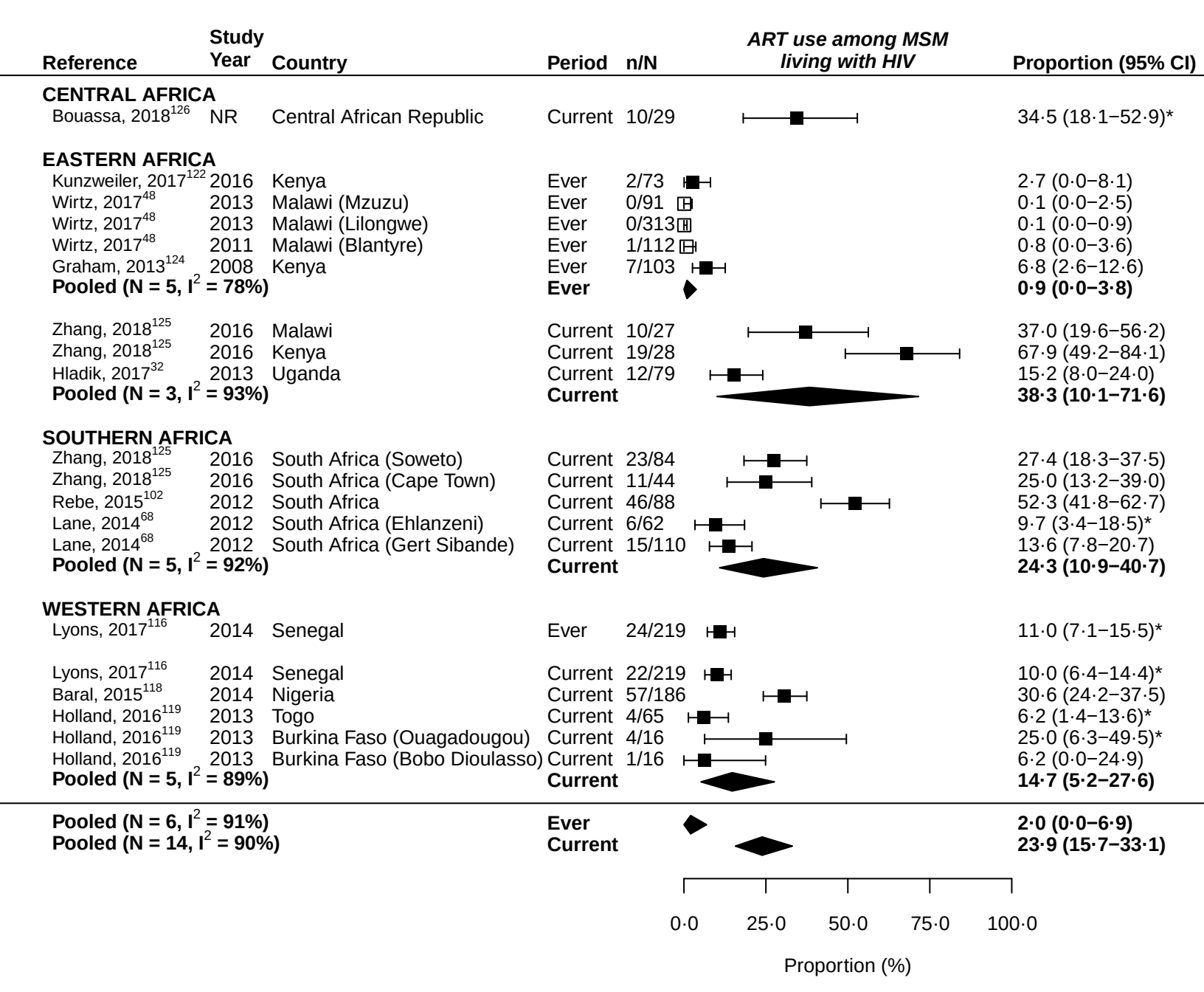


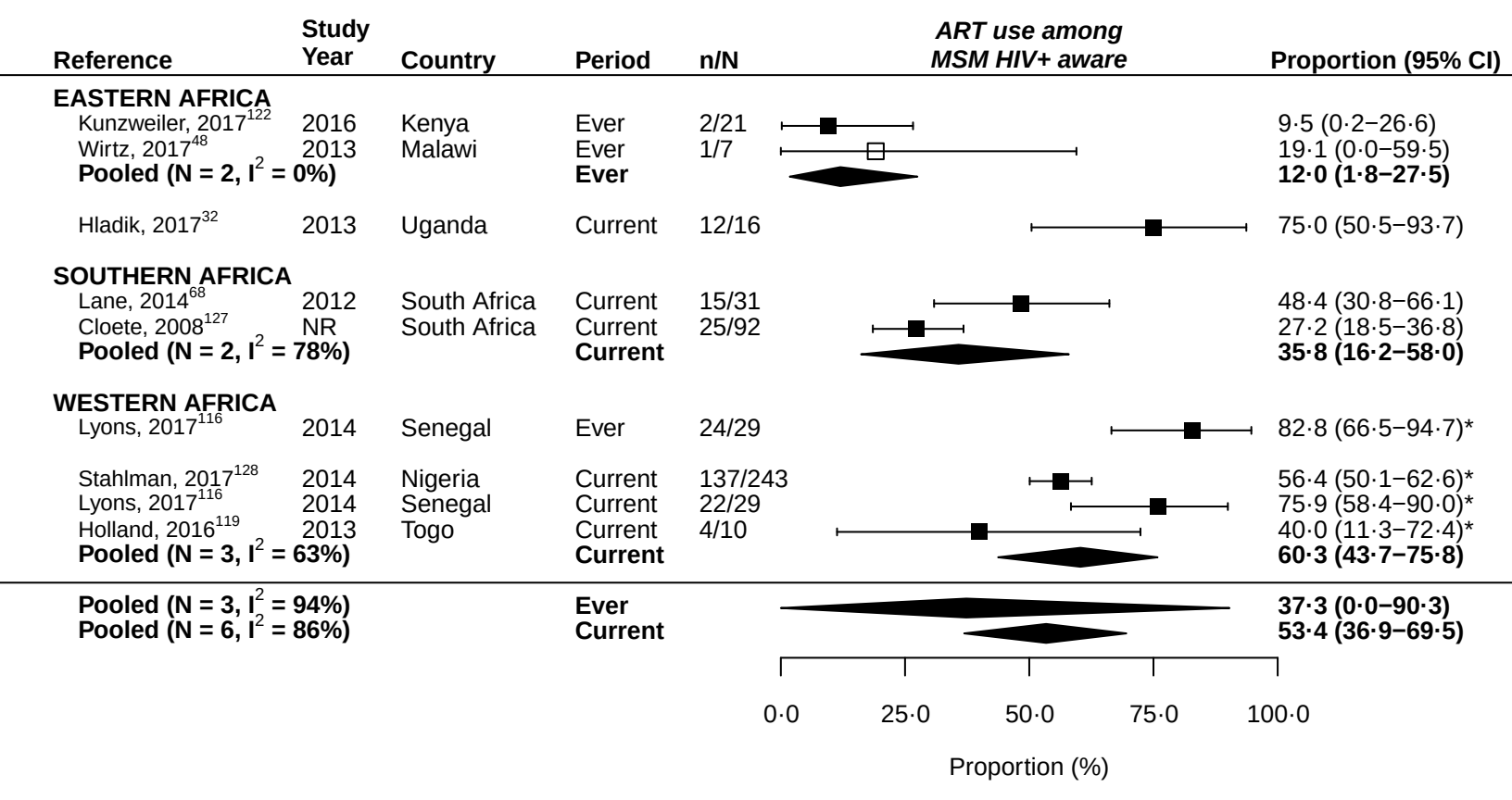
Reference	Study Year	Country	Period	n/N	*Recently Tested*	Proportion (95% CI) *or slope [95% CI]*
CENTRAL AFRICA						
Rao, 2017[98]	2015	Cameroon	12 months	18/32		55·5 (38·0–72·3)
Rao, 2017[98]	2013	Cameroon	12 months	188/212		88·7 (84·0–92·6)
Park, 2014[99]	2011	Cameroon	12 months	75/138		54·3 (45·9–62·5)
Park, 2014[99]	2011	Cameroon	12 months	85/135		63·2 (54·9–71·2)
Kendall, 2014[162]	2011	Angola	12 months	104/328		31·7 (26·8–36·9)*
Pooled (N = 5, I^2 = 98%)			**12 months**			**59·7 (34·4–82·7)**
Slope (Regional time trend: R^2 = 29%, p=0·53)						*0·04 [−0·09–0·18]*
Kendall, 2014[162]	2011	Angola	3 months	52/328		15·9 (12·1–20·0)*
EASTERN AFRICA						
Wirtz, 2017[48]	2014	Malawi	12 months	23/63		36·3 (24·8–48·6)
Wirtz, 2017[48]	2014	Malawi	12 months	16/58		27·6 (16·8–39·9)
Wirtz, 2017[48]	2014	Malawi	12 months	11/61		17·5 (8·8–28·2)
Wirtz, 2017[48]	2014	Malawi	12 months	3/40		6·8 (0·7–17·2)
Shangani, 2017[96]	2014	Kenya	12 months	66/89		74·2 (64·5–82·8)
Coulaud, 2016[46]	2014	Burundi	12 months	44/51		86·3 (75·3–94·6)*
Wirtz, 2017[48]	2013	Malawi	12 months	2/10		24·4 (1·8–57·2)
Wirtz, 2017[48]	2013	Malawi	12 months	5/12		39·8 (13·9–68·7)
Hladik, 2017[32]	2013	Uganda	12 months	104/147		70·9 (63·3–78·0)
Wirtz, 2017[48]	2011	Malawi	12 months	5/24		19·4 (5·7–37·9)
Khatib, 2017[49]	2011	Tanzania	12 months	139/251		55·3 (49·1–61·4)
Horth, 2015[50]	2011	Mozambique	12 months	49/164		29·8 (23·0–37·0)
Horth, 2015[50]	2011	Mozambique	12 months	143/340		42·1 (36·9–47·4)
Horth, 2015[50]	2011	Mozambique	12 months	77/255		30·4 (24·9–36·2)
Muraguri, 2015[51]	2010	Kenya	12 months	268/563		47·6 (43·5–51·7)*
Khatib, 2017[49]	2007	Tanzania	12 months	39/343		11·3 (8·2–14·9)
Adam, 2009[97]	2004	Mauritius	12 months	8/50		16·0 (7·0–27·6)
Pooled (N = 17, I^2 = 96%)			**12 months**			**37·1 (26·9–47·8)**
Slope (Regional time trend: R^2 = 28%, p=0·054)						*0·03 [0·00–0·07]*
Coulaud, 2016[46]	2014	Burundi	6 months	44/51		86·3 (75·3–94·6)*
Raymond, 2009[108]	2004	Uganda	6 months	21/88		23·7 (15·3–33·2)
Pooled (N = 2, I^2 = 98%)			**6 months**			**56·0 (2·9–100·0)**
Coulaud, 2016[46]	2014	Burundi	3 months	35/51		68·6 (55·1–80·7)*
Bhattacharjee, 2015[109]	2014	Kenya	3 months	964/1308		73·7 (71·3–76·1)
Pooled (N = 2, I^2 = 0%)			**3 months**			**73·8 (71·4–76·2)**
NORTHERN AFRICA						
Valadez, 2013[100]	2010	Libya	12 months	79/174		45·6 (38·2–53·1)
SOUTHERN AFRICA						
Lippman, 2018[101]	2016	South Africa	12 months	45/72		62·5 (51·0–73·4)*
Lippman, 2018[101]	2015	South Africa	12 months	39/55		70·9 (58·1–82·3)*
Rao, 2017[98]	2014	eSwatini	12 months	121/136		89·0 (83·1–93·7)
Rebe, 2015[102]	2012	South Africa	12 months	107/200		53·5 (46·6–60·4)
Grover, 2016[103]	2011	eSwatini	12 months	177/326		54·3 (48·9–59·7)
Baral, 2011[104]	2009	Lesotho	12 months	128/235		54·5 (48·1–60·8)
Knox, 2011[73]	2008	South Africa	12 months	120/300		40·0 (34·5–45·6)
Pooled (N = 7, I^2 = 95%)			**12 months**			**61·2 (48·8–72·9)**
Slope (Regional time trend: R^2 = 51%, p=0·014)						*0·04 [0·01–0·07]*
Lippman, 2018[101]	2016	South Africa	6 months	37/72		51·4 (39·8–62·9)
Lippman, 2018[101]	2015	South Africa	6 months	11/55		20·0 (10·3–31·7)
Lane, 2008[76]	2004	South Africa	6 months	46/147		31·3 (24·0–39·0)*
Pooled (N = 3, I^2 = 86%)			**6 months**			**33·8 (18·8–50·6)**
WESTERN AFRICA						
Tun, 2018[78]	2017	Nigeria	12 months	147/319		46·1 (40·6–51·6)*
Lahuerta, 2018[82]	2014	Mali	12 months	114/241		47·1 (40·8–53·4)
Bouscaillou, 2016[105]	2014	Cote d'Ivoire	12 months	15/40		37·5 (23·0–53·1)
Girault, 2015[85]	2013	Ghana	12 months	17/59		28·9 (18·0–41·2)
Girault, 2015[85]	2013	Ghana	12 months	28/45		62·6 (47·8–76·3)
Nelson, 2015[106]	2012	Ghana	12 months	80/92		87·0 (79·2–93·2)*
Aho, 2013[107]	2011	Cote d'Ivoire	12 months	99/310		32·1 (27·0–37·4)
Adam, 2009[97]	2007	Nigeria	12 months	265/877		30·2 (27·2–33·3)
Adam, 2009[97]	2006	Mauritania	12 months	4/26		15·4 (3·6–32·2)
Pooled (N = 9, I^2 = 95%)			**12 months**			**43·4 (32·3–54·9)**
Slope (Regional time trend: R^2 = 0%, p=0·15)						*0·03 [−0·01–0·06]*
Tun, 2018[78]	2017	Nigeria	6 months	56/319		17·6 (13·6–21·9)
Tobin−West, 2017[80]	2014	Nigeria	6 months	45/101		44·6 (35·0–54·4)*
Nelson, 2015[106]	2012	Ghana	6 months	59/92		64·1 (54·0–73·7)*
Pooled (N = 3, I^2 = 98%)			**6 months**			**40·9 (13·9–71·2)**
Nelson, 2015[106]	2012	Ghana	3 months	23/92		25·0 (16·6–34·4)*
MULTIPLE REGIONS						
Herce, 2018[43]	2017	Malawi/Angola	6 months	164/828		19·8 (17·2–22·6)
Pooled (N = 39, I^2 = 97%)			**12 months**			**46·2 (39·6–52·9)**
Slope (Overall time trend: R^2 = 22%, p=0·0015)						*0·04 [0·01–0·06]*
*Time*region interaction (R^2 = 4%, p=0·97)*						
Pooled (N = 9, I^2 = 96%)			**6 months**			**38·8 (26·0–52·4)**
Pooled (N = 4, I^2 = 99%)			**3 months**			**44·9 (11·3–81·3)**




Reference
Study Year
Country
n/N
MSM living with HIV aware of their status
Proportion (95% CI) or slope [95% CI]
CENTRAL AFRICA
Herce, 2018[43] 2017 Angola (Benguela) 1/10 10·0 (0·0−38·1)
Herce, 2018[43] 2017 Angola (Luanda) 3/10 30·0 (5·0−62·5)
Kendall, 2014[62] 2011 Angola 10/27 37·0 (19·6−56·2)*
Pooled (N = 3, I² = 20%) 29·0 (15·1−45·0)
EASTERN AFRICA
Fogel, 2018[121] 2016 Malawi 9/27 33·3 (16·6−52·4)*
Fogel, 2018[121] 2016 Kenya 10/28 35·7 (18·8−54·5)*
Kunzweiler, 2017[122] 2016 Kenya 21/75 28·0 (18·4−38·8)
Wirtz, 2017[48] 2014 Malawi (Mulanje) 0/24 1·3 (0·0−11·6)
Wirtz, 2017[48] 2014 Malawi (Mangochi) 0/52 0·6 (0·0−5·4)
Wirtz, 2017[48] 2013 Malawi (Mzuzu) 0/78 0·1 (0·0−2·8)
Wirtz, 2017[48] 2013 Malawi (Lilongwe) 0/127 0·1 (0·0−1·9)
Hladik, 2017[32] 2013 Uganda 16/79 20·3 (12·0−29·9)
Ross, 2014[110] 2012 Tanzania 5/62 8·1 (2·3−16·4)
Wirtz, 2017[48] 2011 Malawi (Blantyre) 1/37 3·2 (0·0−12·2)
Muraguri, 2015[51] 2010 Kenya 49/144 34·0 (26·5−42·0)*
Baral, 2009[111] 2008 Malawi 2/43 4·7 (0·1−13·5)
Sanders, 2007[58] 2006 Kenya 7/70 10·0 (3·9−18·3)*
Pooled (N = 13, I² = 93%) 10·1 (3·3−19·5)
SOUTHERN AFRICA
Fogel, 2018[121] 2016 South Africa (Soweto) 38/84 45·2 (34·7−56·0)*
Fogel, 2018[121] 2016 South Africa (Cape Town) 10/44 22·7 (11·4−36·4)*
Stahlman, 2015[112] 2014 Lesotho 69/172 40·1 (32·9−47·6)*
Lane, 2014[68] 2012 South Africa (Ehlanzeni) 9/62 14·5 (6·7−24·5)
Lane, 2014[68] 2012 South Africa (Gert Sibande) 31/110 28·2 (20·1−37·0)
Brown, 2016[113] 2011 eSwatini 19/55 34·5 (22·5−47·7)*
Baral, 2011[114] 2009 South Africa 3/50 6·0 (0·8−14·7)
Lane, 2011[115] 2008 South Africa 8/69 11·6 (4·9−20·4)*
Baral, 2009[111] 2008 Namibia 16/27 59·3 (40·0−77·2)
Baral, 2009[111] 2008 Botswana 4/23 17·4 (4·2−36·0)
Pooled (N = 10, I² = 87%) 26·4 (17·1−36·7)
WESTERN AFRICA
Lyons, 2017[116] 2014 Senegal 29/219 13·2 (9·0−18·1)
Hakim, 2017[117] 2014 Mali 10/79 13·3 (6·6−21·8)
Baral, 2015[118] 2014 Nigeria 113/399 28·3 (24·0−32·8)
Holland, 2016[119] 2013 Togo 10/65 15·4 (7·5−25·3)
Holland, 2016[119] 2013 Burkina Faso (Ouagadougou) 5/16 31·3 (10·5−56·4)
Holland, 2016[119] 2013 Burkina Faso (Bobo Dioulasso) 5/16 31·3 (10·5−56·4)
Drame, 2013[87] 2012 Senegal 20/41 48·8 (33·5−64·2)*
Mason, 2013[120] 2011 The Gambia 1/20 5·0 (0·0−20·2)*
Hakim, 2015[88] 2011 Cote d'Ivoire 6/46 13·6 (5·0−25·2)
Pooled (N = 9, I² = 83%) 20·4 (13·2−28·7)
Pooled (N = 35, I² = 91%) 18·2 (13·0−23·9)
Slope (Overall time trend: R² = 0%, p=0·38) 0·01 [−0·01−0·04]
Time*region interaction (R² = 9%, p=0·80)
0·0
25·0
50·0
75·0
100·0
Proportion (%)


Reference
Study Year
Country
n/N
Engagement in Care
Proportion (95% CI)
EVER
Lyons, 2017[116] 2014 Senegal 17/219 7·8 (4·5−11·7)
Baral, 2015[118] 2014 Nigeria 74/110 67·3 (58·2−75·8)*
Pooled (N = 2, I2 = 99%) 33·7 (0·0−92·5)
CURRENT
Ogunbajo, 2017[123] 2015 Ghana 21/30 70·0 (52·2−85·3)*
Graham, 2013[124] 2008 Kenya 16/105 15·2 (8·9−22·8)*
Pooled (N = 2, I2 = 97%) 40·4 (0·9−91·0)
LINKED TO CARE WITHIN 30 DAYS
Lane, 2014[68] 2012 South Africa (Ehlanzeni) 7/62 11·3 (4·4−20·5)
Lane, 2014[68] 2012 South Africa (Gert Sibande) 20/110 18·2 (11·5−26·0)
Pooled (N = 2, I2 = 26%) 15·3 (9·3−22·3)
0·0
25·0
50·0
75·0
100·0
Proportion (%)


Reference
Study Year
Country
Period
n/N
ART use among MSM living with HIV
Proportion (95% CI)
CENTRAL AFRICA
Bouassa, 2018[126] NR Central African Republic Current 10/29 34·5 (18·1–52·9)*
EASTERN AFRICA
Kunzweiler, 2017[122] 2016 Kenya Ever 2/73 2·7 (0·0–8·1)
Wirtz, 2017[48] 2013 Malawi (Mzuzu) Ever 0/91 0·1 (0·0–2·5)
Wirtz, 2017[48] 2013 Malawi (Lilongwe) Ever 0/313 0·1 (0·0–0·9)
Wirtz, 2017[48] 2011 Malawi (Blantyre) Ever 1/112 0·8 (0·0–3·6)
Graham, 2013[124] 2008 Kenya Ever 7/103 6·8 (2·6–12·6)
Pooled (N = 5, I2 = 78%) Ever 0·9 (0·0–3·8)
Zhang, 2018[125] 2016 Malawi Current 10/27 37·0 (19·6–56·2)
Zhang, 2018[125] 2016 Kenya Current 19/28 67·9 (49·2–84·1)
Hladik, 2017[32] 2013 Uganda Current 12/79 15·2 (8·0–24·0)
Pooled (N = 3, I2 = 93%) Current 38·3 (10·1–71·6)
SOUTHERN AFRICA
Zhang, 2018[125] 2016 South Africa (Soweto) Current 23/84 27·4 (18·3–37·5)
Zhang, 2018[125] 2016 South Africa (Cape Town) Current 11/44 25·0 (13·2–39·0)
Rebe, 2015[102] 2012 South Africa Current 46/88 52·3 (41·8–62·7)
Lane, 2014[68] 2012 South Africa (Ehlanzeni) Current 6/62 9·7 (3·4–18·5)*
Lane, 2014[68] 2012 South Africa (Gert Sibande) Current 15/110 13·6 (7·8–20·7)
Pooled (N = 5, I2 = 92%) Current 24·3 (10·9–40·7)
WESTERN AFRICA
Lyons, 2017[116] 2014 Senegal Ever 24/219 11·0 (7·1–15·5)*
Lyons, 2017[116] 2014 Senegal Current 22/219 10·0 (6·4–14·4)*
Baral, 2015[118] 2014 Nigeria Current 57/186 30·6 (24·2–37·5)
Holland, 2016[119] 2013 Togo Current 4/65 6·2 (1·4–13·6)*
Holland, 2016[119] 2013 Burkina Faso (Ouagadougou) Current 4/16 25·0 (6·3–49·5)*
Holland, 2016[119] 2013 Burkina Faso (Bobo Dioulasso) Current 1/16 6·2 (0·0–24·9)
Pooled (N = 5, I2 = 89%) Current 14·7 (5·2–27·6)
Pooled (N = 6, I2 = 91%) Ever 2·0 (0·0–6·9)
Pooled (N = 14, I2 = 90%) Current 23·9 (15·7–33·1)
0·0
25·0
50·0
75·0
100·0
Proportion (%)


Reference
Study Year
Country
Period
n/N
ART use among MSM HIV+ aware
Proportion (95% CI)
EASTERN AFRICA
Kunzweiler, 2017[122] 2016 Kenya Ever 2/21 9·5 (0·2–26·6)
Wirtz, 2017[48] 2013 Malawi Ever 1/7 19·1 (0·0–59·5)
Pooled (N = 2, I² = 0%) Ever 12·0 (1·8–27·5)
Hladik, 2017[32] 2013 Uganda Current 12/16 75·0 (50·5–93·7)
SOUTHERN AFRICA
Lane, 2014[68] 2012 South Africa Current 15/31 48·4 (30·8–66·1)
Cloete, 2008[127] NR South Africa Current 25/92 27·2 (18·5–36·8)
Pooled (N = 2, I² = 78%) Current 35·8 (16·2–58·0)
WESTERN AFRICA
Lyons, 2017[116] 2014 Senegal Ever 24/29 82·8 (66·5–94·7)*
Stahlman, 2017[128] 2014 Nigeria Current 137/243 56·4 (50·1–62·6)*
Lyons, 2017[116] 2014 Senegal Current 22/29 75·9 (58·4–90·0)*
Holland, 2016[119] 2013 Togo Current 4/10 40·0 (11·3–72·4)*
Pooled (N = 3, I² = 63%) Current 60·3 (43·7–75·8)
Pooled (N = 3, I² = 94%) Ever 37·3 (0·0–90·3)
Pooled (N = 6, I² = 86%) Current 53·4 (36·9–69·5)
0·0
25·0
50·0
75·0
100·0
Proportion (%)

Reference	Study Year	Country	Denominator	n/N	Viral threshold (copies per mL)	Virally Suppressed	Proportion (95% CI)
EASTERN AFRICA							
Kunzweiler, 2017[122]	2016	Kenya	MSM living with HIV	23/74	<1000		31·1 (21·0–42·1)
Hladik, 2017[32]	2013	Uganda	MSM living with HIV	5/27	<1000		19·3 (6·2–36·7)
Pooled (N = 2, I^2 = 20·8%)			**MSM living with HIV**				**27·1 (17·3–38·2)**
Kunzweiler, 2017[122]	2016	Kenya	MSM HIV+ Aware	7/21	<1000		33·3 (14·5–55·1)*
Hladik, 2017[32]	2013	Uganda	MSM HIV+ Aware	8/16	<1000		50·0 (25·4–74·6)
Pooled (N = 2, I^2 = 0·0%)			**MSM HIV+ Aware**				**40·4 (24·7–57·1)**
Hladik, 2017[32]	2013	Uganda	Currently on ART	7/12	<1000		58·3 (29·0–85·1)
WESTERN AFRICA							
Schwartz, 2015[129]	2014	Nigeria	MSM living with HIV	31/161	<50		19·3 (13·5–25·7)
Stahlman, 2017[128]	2014	Nigeria	MSM HIV+ Aware	69/204	<200		33·8 (27·5–40·5)
Lyons, 2017[116]	2014	Senegal	Currently on ART	14/22	<1000		63·6 (42·2–82·7)
Charurat, 2015[130]	2013	Nigeria	Currently on ART	37/46	<200		80·4 (67·6–90·8)
Pooled (N = 2, I^2 = 53%)			**Currently on ART**				**73·9 (56·2–88·6)**
MULTIPLE REGIONS							
Zhang, 2018[125]	2016	Kenya, Malawi, South Africa	MSM living with HIV	52/183	<400		28·4 (22·1–35·2)*
Zhang, 2018[125]	2016	Kenya, Malawi, South Africa	Currently on ART	52/63	<400		82·5 (72·1–91·0)
Pooled (N = 4, I^2 = 49%)			**MSM living with HIV**				**24·7 (18·8–31·2)**
Pooled (N = 3, I^2 = 0%)			**MSM HIV+ Aware**				**34·4 (28·3–40·7)**
Pooled (N = 4, I^2 = 45%)			**Currently on ART**				**75·6 (64·4–85·5)**