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# Trends in HIV testing, the treatment cascade, and HIV incidence among men who have sex with men in Africa: A systematic review and meta-regression analysis

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## ABSTRACT

### Background

Gay, bisexual, and other men who have sex with men (MSM) are disproportionately affected by HIV. In Africa, MSM face structural barriers to HIV prevention and treatment including socio-economic disadvantages, stigma, and criminalization that increase their vulnerability to HIV acquisition and transmission and undermine progress towards ending AIDS. This systematic review explores progress towards increases in HIV testing, improving engagement in the HIV treatment cascade, and HIV incidence reductions among MSM in Africa.

### Methods

We searched Embase, Medline, Global Health, Scopus, and Web of Science from January 1980-March 2022 for cross-sectional and longitudinal studies reporting HIV testing, knowledge of status, care, antiretroviral therapy (ART) use, viral suppression, and/or HIV incidence among MSM in Africa. We pooled surveys using Bayesian generalized linear mixed-effects models, used meta-regression to assess time trends, and compared HIV incidence estimates among MSM with those of all men.

### Findings

Of 8,992 articles identified, we included 148 unique studies published from 2005-2022. HIV testing increased over time in Central/Western and Eastern Africa and in 2020, we estimate that 88% (95% credible interval (CrI) 57-97%) of MSM had tested in the past 12 months, but 66% (19-94%) of MSM living with HIV knew their HIV status, although this is probably underestimated given non-disclosure. Current ART use increased over time in Central/Western ( $OR_{year}=1.4$ , 95%CrI 1.1-2.0, N=8) and Eastern/Southern Africa ( $OR_{year}=1.4$ , 1.0-1.8, N=17) and in 2020 we estimate that 75% (18-98%) of MSM living with HIV in Africa were currently on ART. Nevertheless, we did not find strong evidence viral suppression increased, and in 2020 we estimate that only 62% (12-95%) of MSM living with HIV were virally suppressed. HIV incidence among MSM did not decrease over time ( $IRR_{year}=1.0$ , 0.7-1.3, N=38) and remained high in 2020

(5.4 per 100 person-years, 0.9-33.9) and substantially higher (27-150 times higher) than among all men.

### **Interpretation**

No decreases in HIV incidence have been observed among MSM in Africa over time, despite some increases in HIV testing and ART use. Achieving the UNAIDS 95-95-95 targets for diagnosis, treatment, and viral suppression equitably for all requires renewed focus on this key population. Combination interventions for MSM are urgently required to reduce disparities in HIV incidence and tackle the social, structural, and behavioural factors that make MSM vulnerable to HIV acquisition.

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## INTRODUCTION

Globally, gay, bisexual, and other men who have sex with men (MSM) and other key populations experience a disproportionate burden of HIV<sup>1</sup>. Key populations are individuals who are vulnerable to HIV acquisition and transmission and who experience unmet HIV prevention needs. In 2021, members of key populations and their sexual partners accounted for 70% of new annual HIV infections globally and 21% occurred among MSM<sup>1</sup>. Globally, MSM may be up to 28 times more likely to acquire HIV compared to heterosexual men<sup>1</sup>. Vulnerabilities to HIV can be partly explained by sexual behaviours, but the sociocultural and political contexts in which MSM live are important drivers of these vulnerabilities. Today, MSM face criminalization in 70 countries, including 31 in Africa<sup>2</sup>. In many settings, they are marginalized for their sexual identities and behaviours and face violence, stigma, and discrimination<sup>1-4</sup>. These punitive and discriminatory norms and legislations often impede access to primary HIV prevention and the treatment and care cascade, exacerbating susceptibilities to HIV acquisition and transmission. To “End AIDS”, the Global AIDS Strategy 2021-2026 calls for equitable and equal access to HIV services, as well as breaking down legal and societal barriers to achieving HIV outcomes<sup>5</sup>.

In 2021, an estimated 18% of new annual HIV acquisitions in Central and Western Africa occurred among MSM, compared to 3% in Eastern and Southern Africa, where epidemics are more generalized<sup>1</sup>. Despite this, HIV prevalence is much higher among MSM than the general population in all regions of Africa, highlighting the need for contextualized approaches to HIV prevention, and MSM-focused interventions across epidemic typologies<sup>1</sup>.

As with other key populations, MSM can be hard to reach, and nationally representative data on HIV service utilization and incidence are not available. This poses challenges to evaluating progress towards ending AIDS. The UNAIDS 95-95-95 targets for 2025 calls for 95% knowledge of status among those living with HIV, 95% treatment coverage among those diagnosed, and 95% viral suppression among those on treatment. Increasingly, dedicated surveys are being carried out to collect such indicators among MSM in Africa and to identify barriers and improve uptake of services to reduce new infections.

A previous systematic review and meta-analysis of HIV testing and the HIV treatment cascade from 2004-2017 among MSM in Africa reported that levels of diagnosis, treatment, and viral suppression were too low to achieve the previous UNAIDS 90-90-90 targets for 2020<sup>6</sup>. Here, we update and substantially expand on this previous review to improve our understanding of temporal trends in HIV testing, knowledge of status, care, treatment coverage, and viral suppression, and HIV incidence among MSM, and to evaluate progress towards achieving the new UNAIDS 95-95-95 targets for 2025 and ending AIDS among MSM in Africa.

## METHODS

### Search strategy and data extraction

We searched Web of Science, Scopus, and Ovid Embase, MEDLINE, and Global Health online databases for articles reporting HIV testing, knowledge of status, engagement in care, antiretroviral therapy (ART) use, viral suppression, or HIV incidence among MSM in Africa, published from January 1<sup>st</sup>, 1980, up to March 24<sup>th</sup>, 2022, using search terms for HIV, MSM, and Africa (Table S1).

We first screened articles by title and abstract, and then screened full texts for eligible studies. We included peer-reviewed cross-sectional or longitudinal studies that were conducted in any African country. We excluded conference abstracts, posters, and presentations, review articles, mathematical modelling studies, qualitative studies, and policy analyses. We did not exclude studies based on language. We perused the bibliographies of reviews and full texts for further relevant articles.

From the included studies, we extracted or calculated the following outcomes:

- 1) proportions of MSM who self-reported ever testing for HIV;
- 2) proportions of MSM who self-reported testing for HIV in the past 3, 6, and 12 months;
- 3) proportions of MSM living with HIV (confirmed with a biomarker) who knew they were living with HIV (from self-reports only or complemented with biomarkers, hereafter referred to as HIV aware MSM);
- 4) proportions of MSM living with HIV who self-reported engagement in care (as defined by study authors)
- 5) proportions of MSM living with HIV or HIV aware MSM, who were currently on ART (from self-reports or biomarkers)
- 6) proportions of MSM living with HIV, HIV aware MSM, or MSM currently on ART who were virally suppressed (confirmed with viral load testing and based on viral thresholds defined by study authors);
- 7) HIV incidence rates among MSM.

We also extracted information on participants (e.g., study population, age,), study characteristics (e.g., study design, region of Africa, country, study years), and indicators of study quality (e.g., sampling methods, definitions of MSM employed by studies, and interview methods).

When multiple articles reported observations of the same outcome from the same study, we extracted the observation derived from the largest sample size. For studies that included transgender women (TGW), where possible, we included observations among MSM only, otherwise we used the aggregate observation reported. For studies conducted in multiple countries, we extracted observations for each country separately, if reported, otherwise we used the aggregate observation but did not assign it a specific country. For studies conducted in multiple sub-national regions of a single country, we extracted only the aggregate observation. In studies of HIV incidence that reported multiple observations over consecutive non-overlapping follow-up periods, these were, otherwise we considered only the incidence rate

covering the total follow-up period. In studies that reported them, weighted observations that accounted for sampling method (e.g., respondent-driven sampling, cluster, or time-location sampling) were preferred over to crude observations (Text S1).

Screening and data extraction were conducted by three independent reviewers (JS, NS, and JKSL). Discrepancies were resolved by KG. This systematic review and meta-regression analysis were completed according to PRISMA guidelines<sup>7</sup>.

## Data analyses

To pool observations and obtain region- and country-level estimates of HIV testing, stages in the HIV treatment cascade, and HIV incidence over time, we performed meta-regression analyses using Bayesian generalized linear mixed-effects models. Outcomes needed a minimum of 10 survey observations to be pooled. A Bayesian multilevel framework was chosen because MSM survey estimates are heterogeneous, data is sparse geographically, and few countries have several surveys<sup>6</sup>. In our models, we included study-level random intercepts, nested within country and region, allowing us to improve the accuracy and precision of estimates in settings with fewer observations<sup>8</sup>. To assess time trends, we used the mean-centered calendar year (or year and month for HIV incidence) as a continuous variable (using the midpoint year of each study), with random slopes by country, nested within regions. Regions were classified as Central/Western, Eastern/Southern, and Northern Africa based on UNAIDS' classifications<sup>1</sup>. If both Central and Western Africa or Eastern and Southern Africa had >10 survey observations, we included those regions separately in our analyses. We modelled proportions of ever and recent HIV testing, knowledge of status, ART use, and viral suppression using a binomial likelihood. For HIV incidence rates, we used a Poisson likelihood with log(person-time) as an offset. We did not weight countries by their estimated numbers of MSM given wide variations and uncertainties in these population size estimates<sup>9-11</sup>. We used non-informative prior distributions on the model parameters and elicited weakly informative prior distributions on the group-level variance parameters of the random effects (Text S2). Posterior distributions were obtained using Hamiltonian Monte Carlo, implemented in Stan<sup>12</sup>, and summarized using medians and 95% credible intervals (CrI). We reported time trends for countries with observations from at least three different time points. Finally, we compared our estimates of knowledge of status, current ART use, and viral suppression among MSM living with HIV, and HIV incidence with year-matched UNAIDS estimates for all men<sup>13</sup>.

We assessed the risk of bias in included studies by appraising studies according to five criteria covering the appropriateness of the sampling method, statistical adjustment for complex survey design, the representativeness of the study population of MSM, the inclusion of transgender women as MSM in surveys, and the risk of misclassification in ascertaining study outcomes (further details in Text S3). Studies received a score ranging from 0-5 for each outcome reported, representing higher (score 0-1), moderate (score 2-3), and lower (score 4-5) risk of bias in reported study outcomes. We assessed publication bias using funnel plots.

Analyses were conducted in R, version 4.0.2, using the “brms” and “rstan” packages<sup>14,15</sup>.

## RESULTS

### Search results

We initially identified 19,419 publications and, after removing 10,427 duplicates, and 7,921 publications at the title and abstract screening stage, we assessed the eligibility of 1,071 full texts (Figure S1). Four additional articles were identified from bibliographies of relevant articles. Overall, we included 231 articles from 147 unique studies (Table 1), nearly doubling the number of studies identified in a previous systematic review (Figure S2)<sup>6</sup>.

**Table 1.** Number of unique studies included in our review that reported (a) HIV incidence, testing, and treatment cascade outcomes among men who have sex with men (MSM) in Africa, and summary of (b) study characteristics, (c) participant characteristics, and (d) study quality, of included studies, and references of individual publications that provided observations that were included in our analyses.

	Total unique studies* (N <sub>s</sub> =147)	References
<b>(a) HIV incidence, testing, and treatment cascade outcomes</b>		
<b>HIV incidence rate</b> (among MSM not living with HIV)	30	16-36
<b>HIV testing</b> (among all MSM)	114	16,18-20,37-137
Ever	93	16,18,20,37-115
Past 12 months	44	19,41- 44,50,57,61,63,67,73,76,85,86,100,106,108,112,113,116-131
Past 6 months	23	19,42,59,61,81,85- 87,96,99,103,106,108,110,112,132-137
Past 3 months	9	42,50,61,62,99,106,108,112,113
<b>Knowledge of status</b> (among MSM living with HIV)	41	18,30,40,50,58,63,66,67,76,81,86,105,107,108,112,113,115,125,136-151
<b>Engagement in Care</b> (among MSM living with HIV)	16	25,67,86,112,115,136,141,145,152-162
Ever in care (non-ART)	3	141,145,152
Ever on ART	7	67,112,141,145,153-155
Currently in care (non-ART)	6	86,112,136,154,156-158
Linked to care within 3 months	1	159
Linked to care within 30 days	3	115,160,163
Retained in care in the past 12 months	1	161
Retained in care in the past 6 months	2	159,162
<b>Currently on ART</b>	29	16,76,86,105,107,108,111-113,115,121,136-138,140,141,145,151,164-172
Among MSM living with HIV	25	16,76,86,105,107,108,112,113,115,121,136-138,141,145,151,164-170
Among HIV aware MSM	17	76,86,105,108,111-113,115,138,140,141,151,166,171,172
<b>Viral suppression</b>	20	16,76,86,105,108,111,113,125,136,137,140,141,151,155,158,166,169,171,173-178
Among MSM living with HIV	16	76,105,108,113,125,136,137,166,169,171,173-177
Among HIV aware MSM	10	76,86,105,111,125,140,151,155,171,178
Among MSM currently on ART	12	16,76,86,105,108,111,113,141,151,158,169,171
<b>b) Study characteristics</b>		



<b>Study midpoint year†</b>		
2011-2020	107	17,27,29,30,32-34,40-44,48,50,52,62,69,72,73,76,80,83,85,86,88,89,91-93,96,98,99,101,104,105,108-110,112-115,117,122,126,129,131,135,137,138,140,141,143,145,158,160,162,163,167,173,174,176,179
2010 and earlier	41	20,21,24,35,38,44-47,54-60,63-66,68,70,71,73,75,77,78,97,100,119,120,123,130,132,144,147,154,164,165
NR	6	79,82,90,95,169,172
<b>Region†</b>		
Central Africa	10	29,31,37,38,50,79,81,116,122,125,165
Western Africa	50	16-18,25,26,33,39-49,81,82,84,85,87,89,92,94,97-101,117-119,127,129,133,138-142,152,153,156-159,161-164,168,170,171,173,175
Eastern Africa	52	20-23,27,32,34,35,61-78,81,83,86,88,93,95,96,102-105,111-114,119,124,126,128,132,136,145-148,150,151,154,155,160,166,169,174,177,178,180
Southern Africa	39	19,21,23,24,28,30,36,51-60,78,86,90,91,106-110,115,120-122,130,131,134,135,137,143,144,147,149,167,172,174,176
Northern Africa	2	80,123
<b>Study design†</b>		
Cross-sectional	112	37-64,67-84,87-93,95-114,116-118,120-148,150,151,156,159,161,162,164,165,168-172,176,177,180
Serial cross-sectional surveys	1	36,115
Prospective cohort – follow-up	28	16-23,25-35
Prospective cohort – baseline	6	66,85,148,149,154,167,175
Retrospective cohort – baseline	3	157,158,160
RCT – follow-up	1	24
RCT – baseline	1	178
NR	2	119
<b>Sampling method†</b>		
RDS	52	16,17,19,22,26,36,37,39-41,43-45,48,50,51,56,58,63,67,69,71-73,75-77,83,84,88,89,92,98,100,102,104,105,108,109,111,115-118,122,123,125,127,129,132,133,135-141,143,145,146,151-153,162,171,173,176,177,180
Cluster/time-location sampling	6	62,64,81,112,114
Snowball	38	20,23,28,32,35,38,42,47,49,53,59,68,70,74,78,85,86,90,91,93,95,99,101,110,122,124,126,131,142,144,147,154,155,159,164,166,174
Convenience	58	17,20,21,23-25,27-30,32-34,46,52,55,57,59-61,65,66,79,82,86,87,94,96,97,103,106,107,109,110,113,121,128,130,131,134,141,144,149,150,156,158-161,163,165,167-170,172,174,175,178
Online	2	54,80
NR	5	18,31,119,148,157
<b>Interview method†</b>		



FTFI <sup>‡</sup>	112	16,17,19-23,25-29,32,37-41,43-51,53,56,58,59,63-71,73,74,77-79,81-86,88,89,91-107,109,110,112-118,120-129,131-135,138-145,150-154,156,162-165,167,168,170,171,173,174,176-178,180
Confidential <sup>§</sup>	33	24,30,34-36,42,45,52,54,55,57,60-62,72,75,76,80,87,90,99,108,109,111,130,136,137,146,148,154,155,159,166,172
NR	14	18,31,119,149,157,158,160,169,175
<b>c) Participant characteristics</b>		
<b>Study MSM eligibility criteria<sup>†</sup></b>		
Ever sex with men	28	23,38,43,46,47,59,71,78,81,82,84,86,95,98,101,103,107,114,117,120,139,144,147,154,156,159,164,169,171,174
Sex with men in the past 12 months	41	16-18,22,26,30,35,37,39-41,45,48,51,54,57,67,69,70,87,89,92,96,100,102,105,108,111,112,116,118,121,122,125-129,133,135-138,140-143,145,151-153,173,177,178,180
Sex with men in the past 6 months	20	19,24,36,42,44,50,53,58,63,72,76,81,85,113,115,123,124,146,149,155,166,176
Sex with men in the past 3 months	16	21,25,28,32-34,65,66,73,75,94,110,131
Sex with men occasionally/regularly	2	83,104
Male sex workers	4	20,64,88,97
Self-identified MSM or gay/bisexual	14	28,60,74,77,80,81,90,91,99,106,130,132,148,149,161,167
Peer-identified as MSM	3	29,79,165,168
Involvement with MSM organizations/HIV prevention	2	61,162
NR	22	21,27,31,49,55,56,62,68,81,86,93,109,119,150,157,158,160,163,170,172,175
<b>Study population<sup>†</sup></b>		
General population of MSM	99	16,17,19,22,26-28,30,36-54,56-60,62,67-72,74,76-78,80-85,87,89-93,95,96,98-105,107-109,111-116,118,120,122-130,132,133,135-148,150-153,155,156,160,166,168,171-173,176,177,180
Selected population of MSM	49	18,20,21,23-25,29,32-35,55,61,63-66,73,75,79,86,94,97,106,110,117,121,131,134,149,154,157-159,161-165,167,169,170,174,175,178
Selected population – high risk <sup>¶</sup>	46	20,21,23-25,29,32-35,55,63-66,73,75,79,86,94,97,110,117,121,131,134,149,154,157-159,161-165,167,169,170,174,175,178
Selected population – low risk <sup>  </sup>	3	18,61,106
NR	3	31,119
<b>TGW included<sup>†</sup></b>		
Yes	92	16-19,22-26,30,37-41,43-67,70-80,82,83,85-87,90,92,94,95,100,102,105-108,112,113,115-118,121-125,130,132,133,136-143,145-147,152-156,163,165,169-171,173,174,176-180
No	14	16,27,30,81,84,96,99,111,120,127,134,144,151,158,159
Unclear	43	20,21,28,29,31-36,42,44,68,69,88,89,91,93,97,98,101,103,104,109,110,114,119,126,128,129,131,135,148-150,157,160-162,164,166-168,172,175,179
<b>Mean or median age<sup>†</sup></b>		

15-24	55	16,17,25,26,28,29,33,37,40,41,44,45,47,48,51,52,56,61,64,67,69-72,74,76,78,79,84,86,89,92,94,101,104,108,109,111,112,116,118,123,125,126,132,133,136,138,142-147,155,161,163,168,180
25-34	99	4,16,18-23,25-27,30,32,33,36,38,41-43,46,49,52-55,57-60,62-66,68,69,73-75,77,78,80,82,83,85-88,90,91,93,95-99,102,103,105-108,110,113,115,117,120-124,127,129-135,137-141,147-154,156,157,159,160,162,164,166,167,169,171-178
NR	17	21,24,31,34,35,50,81,100,114,119,128,158

**d) Study quality**

**Risk of bias score (at the outcome-level)**

Lower (4-5)	16	Table S3
Moderate (2-3)	185	Table S3
Higher (0-1)	120	Table S3

Continuous variables were dichotomised at the median value. ART, antiretroviral therapy; FTFI, face-to-face interview; MSM, men who have sex with men; NR, not reported; RCT, randomized controlled trial; RDS, respondent-driven sampling; TGW, transgender women. \* Number of referenced articles differs from the number of studies when multiple articles report on the same study and provide different observations for different testing, cascade, and/or incidence outcomes or a single article reports on multiple studies. † Same study is included in more than one subcategory when multiple articles report on the same study, or a single study was conducted in multiple locations. ‡ Includes n=2 phone interviews. § Confidential interview methods include audio computer-assisted self-interview/computer-assisted self-interview/computer-assisted personal interview, pooling booth surveys, and self-administered questionnaires. ¶ Selected – high risk includes male sex workers, study MSM definitions based on anal sex only in the past 3 months, sex with multiple partners, MSM with sexually transmitted infections, sex with partners living with HIV, or that recruited MSM living with HIV only). || Selected – low risk includes MSM involved in MSM organizations or prevention activities.

Included studies predominantly reported ever HIV testing (number of studies [ $N_s$ ]=93, number of independent observations [ $N_o$ ]=93, number of MSM [ $N_{MSM}$ ]=43,628), testing in the past 12 months ( $N_s$ =44,  $N_o$ =44,  $N_{MSM}$ =21,865), and knowledge of status ( $N_s$ =41,  $N_o$ =41,  $N_{MSM}$ =6,403; Table 1a). Fewer studies reported testing over shorter recall periods ( $N_s$ =27,  $N_o$ =33,  $N_{MSM}$ =9,298), MSM currently on ART ( $N_s$ =29,  $N_o$ =44,  $N_{MSM}$ =4,301), MSM virally suppressed (defined based on viral loads ranging from  $\leq 20$  to  $< 1000$  copies per mL;  $N_s$ =20,  $N_o$ =38,  $N_{MSM}$ =2,981), or HIV incidence ( $N_s$ =30,  $N_o$ =38,  $N_{MSM}$ =5,044; Table 1a). Few observations of engagement in care other than current ART use were available.

Most studies were conducted between 2011-2020 ( $N_s$ =102) and in Western ( $N_s$ =49), Eastern ( $N_s$ =49), and Southern ( $N_s$ =39) Africa (Table 1b). Few studies were from Central ( $N_s$ =9) or Northern ( $N_s$ =2) Africa. Observations were available from 30 countries, including 26 countries with HIV testing data, 24 countries with HIV treatment cascade data, and 12 countries with HIV incidence data. In 96 studies, conducted in 23 countries, sexual partnerships between men were criminalized at the time the study was conducted (Table 1b).

Studies reporting HIV testing and treatment cascade outcomes were primarily cross-sectional ( $N_s$ =121), whilst incidence studies were mostly prospective cohort ( $N_s$ =28). Most studies used

convenience sampling ( $N_s=58$ ) or respondent-driven sampling (RDS,  $N_s=52$ ; Table 1b). When recruiting participants, most studies defined MSM using eligibility criteria based on self-reported sexual behaviours (e.g., anal, anal/oral, and anal/oral/masturbatory sex) with men in the past 12 months ( $N_s=41$ ), and participants were mainly recruited from the general population of MSM ( $N_s=89$ ; Table 1c). However, in over 90% of studies, MSM definitions either included transgender women, or it was unclear whether they did (Table 1c). Overall, study sample sizes ranged from 23 to 5,796 MSM. Enrolled MSM were largely young, with a mean or median age ranging between 25-34 years ( $N_o=85$ ; Table 1c). Face-to-face interviews were primarily used to collect self-reported information ( $N_s=112$ ; Table 1b).

### **HIV testing, the treatment cascade, and HIV incidence among MSM in Africa: estimates for 2020 and time trends**

In 2020, we estimated from self-reports that 87% (95%CrI 31-97%) of MSM had ever tested for HIV (Table 2). We estimated that ever HIV testing increased from 64% (95%CrI 54-74%) in 2010 to 88% (73-95%) in 2020 in Central/Western Africa (Odds Ratio per year [ $OR_{year}$ ]=1.15, 95% CrI 1.02-1.28,  $N_o=33$ ), and from 61% (50-71%) in 2010 to 93% (81-97%) in 2020 in Eastern Africa ( $OR_{year}=1.24$ , 1.09-1.40,  $N_o=33$ ), increasing particularly in Kenya and Tanzania (Figure 1, Table 2, Figure S3, S16). Most observations were available from South Africa and Kenya.

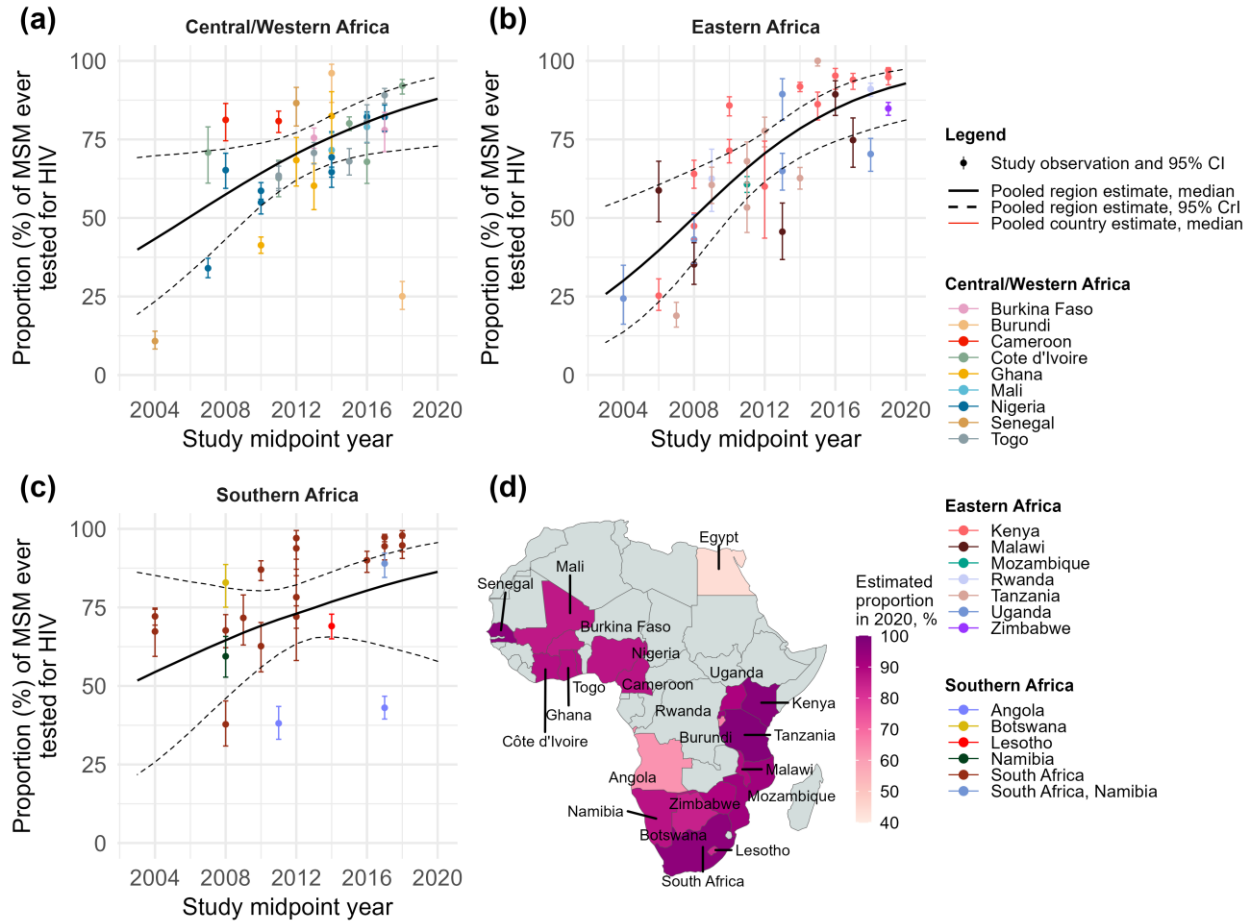
**Table 2. Estimated time trends in HIV testing, treatment cascade, and HIV incidence among men who have sex with men (MSM) in Africa and estimated outcomes in 2010 and 2020, overall and by region of Africa.**

Outcome	Region of Africa	N <sub>o</sub>	Estimate of time trend	95% CrI	Estimate in 2010	95% CrI	Estimate in 2020	95% CrI
<b>Ever HIV testing (%)</b>		89						
	Overall	89	OR=1.11	0.79-1.41	66%	46-85%	87%	31-97%
Among all MSM*	Central/Western Africa	33	<b>OR=1.15</b>	<b>1.02-1.28</b>	<b>64%</b>	<b>54-74%</b>	<b>88%</b>	<b>73-95%</b>
	Eastern Africa	33	<b>OR=1.24</b>	<b>1.09-1.40</b>	<b>61%</b>	<b>50-71%</b>	<b>93%</b>	<b>81-97%</b>
	Southern Africa	22	OR=1.10	0.92-1.27	69%	56-80%	86%	58-96%
<b>Past 12 months HIV testing (%)</b>		44						
	Overall	44	OR=1.23	0.98-1.53	48%	30-66%	88%	57-97%
Among all MSM†	Central/Western Africa	17	<b>OR=1.23</b>	<b>1.06-1.45</b>	<b>48%</b>	<b>34-63%</b>	<b>88%</b>	<b>71-96%</b>
	Eastern Africa	14	<b>OR=1.26</b>	<b>1.09-1.48</b>	<b>45%</b>	<b>29-60%</b>	<b>89%</b>	<b>72-96%</b>
	Southern Africa	12	OR=1.21	0.99-1.44	50%	34-67%	87%	60-96%
<b>Knowledge of status (%)</b>		41						
	Overall	41	OR=1.23	0.98-1.53	15%	4-41%	66%	19-94%
Among MSM living with HIV	Central/Western Africa	9	<b>OR=1.23</b>	<b>1.06-1.45</b>	<b>13%</b>	<b>4-33%</b>	<b>65%</b>	<b>20-95%</b>
	Eastern Africa	17	<b>OR=1.26</b>	<b>1.09-1.48</b>	<b>12%</b>	<b>5-26%</b>	<b>65%</b>	<b>34-88%</b>
	Southern Africa	15	OR=1.24	0.89-1.71	22%	10-44%	66%	22-89%
<b>Currently on ART (%)</b>		42						
	Overall	25	OR=1.37	0.82-2.25	11%	1-67%	75%	18-98%
Among MSM living with HIV	Central/Western Africa	8	<b>OR=1.42</b>	<b>1.08-1.95</b>	<b>10%</b>	<b>2-34%</b>	<b>78%</b>	<b>41-96%</b>
	Eastern/Southern Africa	17	<b>OR=1.36</b>	<b>1.04-1.82</b>	<b>11%</b>	<b>2-39%</b>	<b>73%</b>	<b>39-92%</b>
	Overall	17	OR=1.41	0.73-2.58	25%	1-93%	92%	31-100%
Among HIV aware MSM	Central/Western Africa	5	OR=1.43	0.79-2.05	24%	2-84%	92%	28-100%
	Eastern/Southern Africa	12	OR=1.45	0.98-2.17	25%	3-74%	93%	63-99%
<b>Viral suppression (%)</b>		35						
	Overall	16	OR=1.28	0.69-2.30	12%	0-86%	62%	12-95%
Among MSM living with HIV	Central/Western Africa	4	OR=1.30	0.81-2.20	11%	1-69%	64%	18-96%
	Eastern/Southern Africa	12	OR=1.29	0.95-1.79	11%	1-48%	61%	32-84%
	Overall	10	OR=1.16	0.52-2.50	43%	1-99%	78%	9-99%
Among HIV aware MSM	Central/Western Africa	3	OR=1.13	0.46-2.62	51%	1-99%	79%	5-99%
	Eastern/Southern Africa	7	OR=1.20	0.68-2.08	36%	2-95%	78%	23-97%
	Overall	11	OR=1.17	0.49-2.62	66%	1-100%	91%	24-100%
Among MSM currently on ART	Central/Western Africa	4	OR=1.23	0.51-3.11	67%	1-100%	93%	28-100%
	Eastern/Southern Africa	7	OR=1.16	0.56-2.35	65%	2-100%	89%	39-99%
<b>HIV incidence rate (py<sup>-100</sup>)</b>		38						
	Overall	38	IRR=0.97	0.73-1.32	7.4py <sup>-100</sup>	1.9-27.3	5.4py <sup>-100</sup>	0.9-33.9
Among MSM not living with HIV	Central/Western Africa	17	IRR=0.97	0.82-1.16	8.1py <sup>-100</sup>	3.1-20.6	5.9py <sup>-100</sup>	2.3-14.8
	Eastern/Southern Africa	21	IRR=0.97	0.82-1.16	6.8py <sup>-100</sup>	3.0-15.2	5.0py <sup>-100</sup>	1.6-14.7

ART, antiretroviral therapy; CrI, credible interval; IRR, incidence rate ratio; MSM, men who have sex with men; N<sub>o</sub>, number of observations; OR, odds ratio; py<sup>-100</sup>, per 100 person-years.

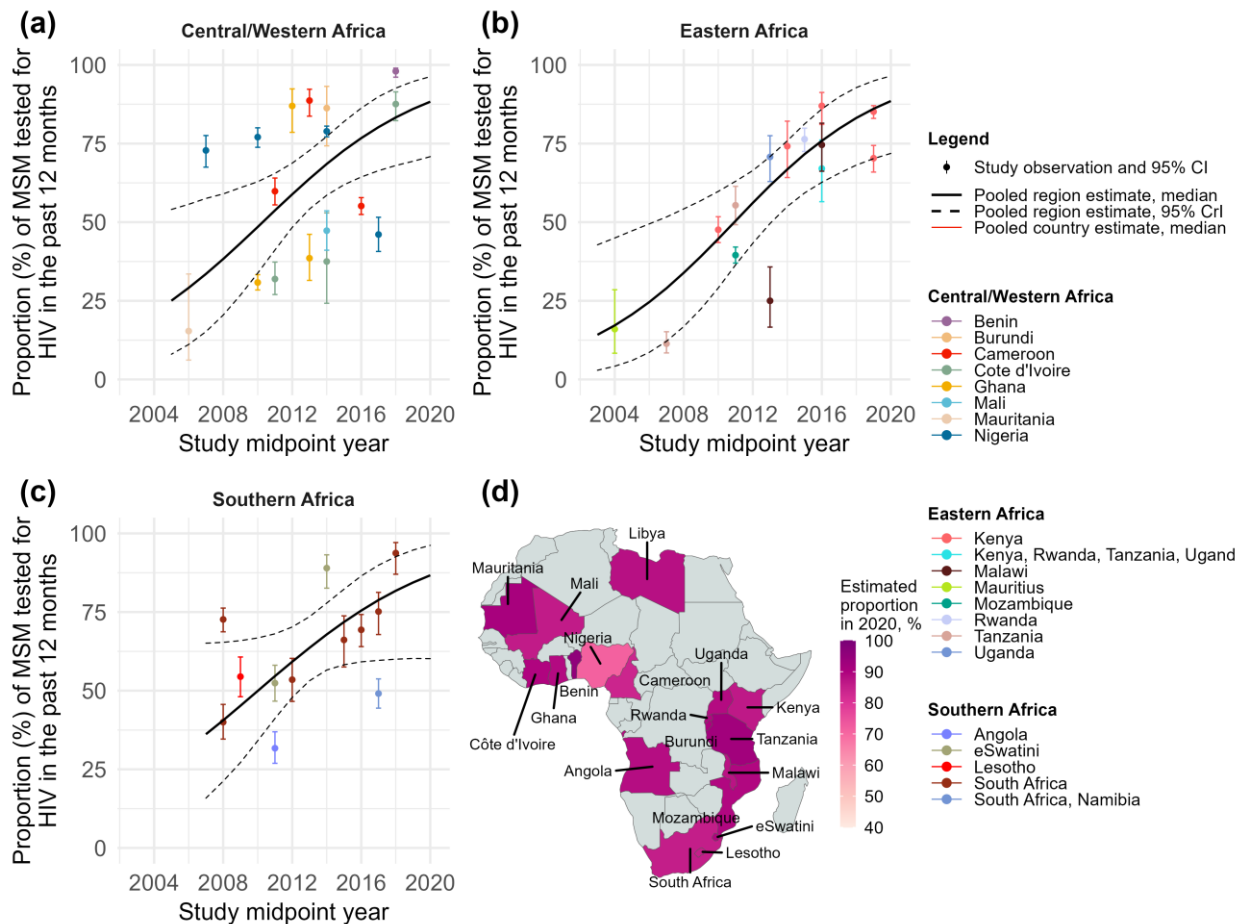
\* n=1 observation from Northern Africa included in analysis but not shown

† n=1 observation from Northern Africa included in analysis but not shown



**Figure 1. Ever HIV testing among men who have sex with men (MSM) over time, by region and country of Africa.** Ever HIV testing among MSM in (a) Central/Western Africa, (b) Eastern Africa, and (c) Southern Africa, and (d) the estimated proportion of MSM ever tested for HIV in 2020, by country, estimated using a Bayesian logistic generalized linear mixed-effects model, with study-, country-, and region-level random effects. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points (see Figure S16 for individual country trends and 95% CrI).

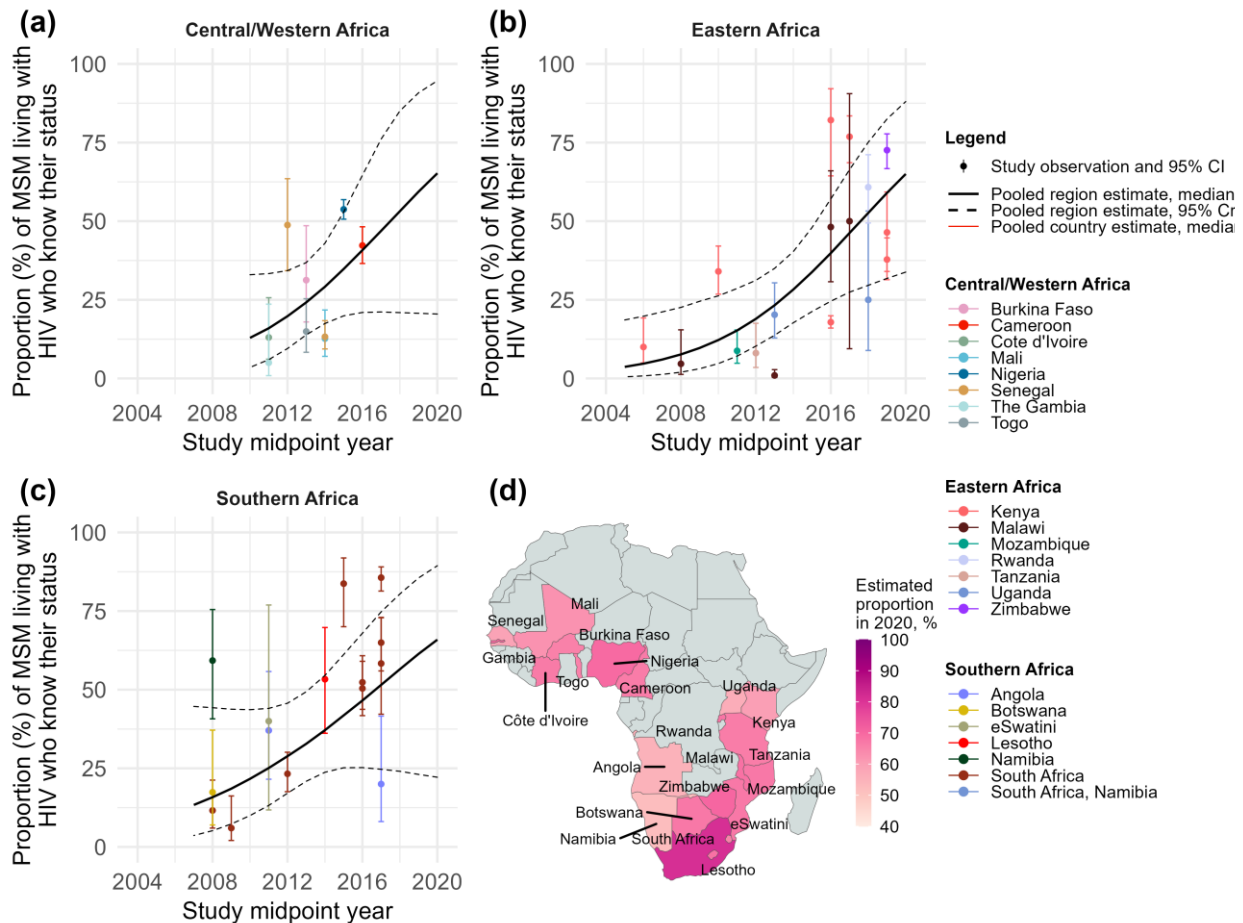
In 2020 we estimated that 88% (57-97%) of MSM in Africa had been tested for HIV in the past 12 months (Table 2). Testing in the past 12 months increased from 48% (34-63%) in 2010 to 88% (71-96%) in 2020 in Central/Western Africa ( $OR_{year}=1.23$ , 1.06-1.45,  $N_o=17$ ), and from 45% (29-60%) in 2010 to 89% (72-96%) in 2020 in Eastern Africa ( $OR_{year}=1.26$ , 1.09-1.48,  $N_o=14$ ), although only one observation was available for most countries (Figure 2, Table 2, Figure S4, S17). In the Southern Africa region, ever and past 12 months testing both seemed to increase, but trends were inconclusive, although clear increases occurred in South Africa (Figure 1c, 2c, Table 2, Figure S16-17). There were not enough observations from Northern Africa, and for HIV testing in the past 3 months, to assess time trends (Figure S6). Time trends in past 6 months HIV testing were inconclusive (Table S2, Figure S5).



**Figure 2. HIV testing in the past 12 months among men who have sex with men (MSM) over time, by region and country of Africa.** Past 12 months HIV testing in (a) Central/Western Africa, (b) Eastern Africa, (c) Southern Africa, and (d) the estimated proportion of MSM tested for HIV in the past 12 months in 2020, by country. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points (see Figure S17 for individual country-level time trends and 95% credible intervals).  $N=1$  observation from Mauritius not shown on the map.



Among MSM living with HIV, we estimated that knowledge of status in 2020 was 66% (19-94%). Knowledge of status increased substantially over time from 13% (4-33%) in 2010 to 65% (20-95%) in 2020 in Central/Western Africa ( $OR_{year}=1.23$ , 1.06-1.45,  $N_0=9$ ) and from 12% (5-26%) in 2010 to 65% (34-88%) in 2020 in Eastern Africa ( $OR_{year}=1.26$ , 1.09-1.48,  $N_0=17$ ) (Figure 3, Table 2, Figure S7, S18). Similar increases in Southern Africa were observed, although trends were inconclusive (Figure 3c, Table 2). In all regions, observations of knowledge of status were heterogenous, and overall only six countries had multiple observations.

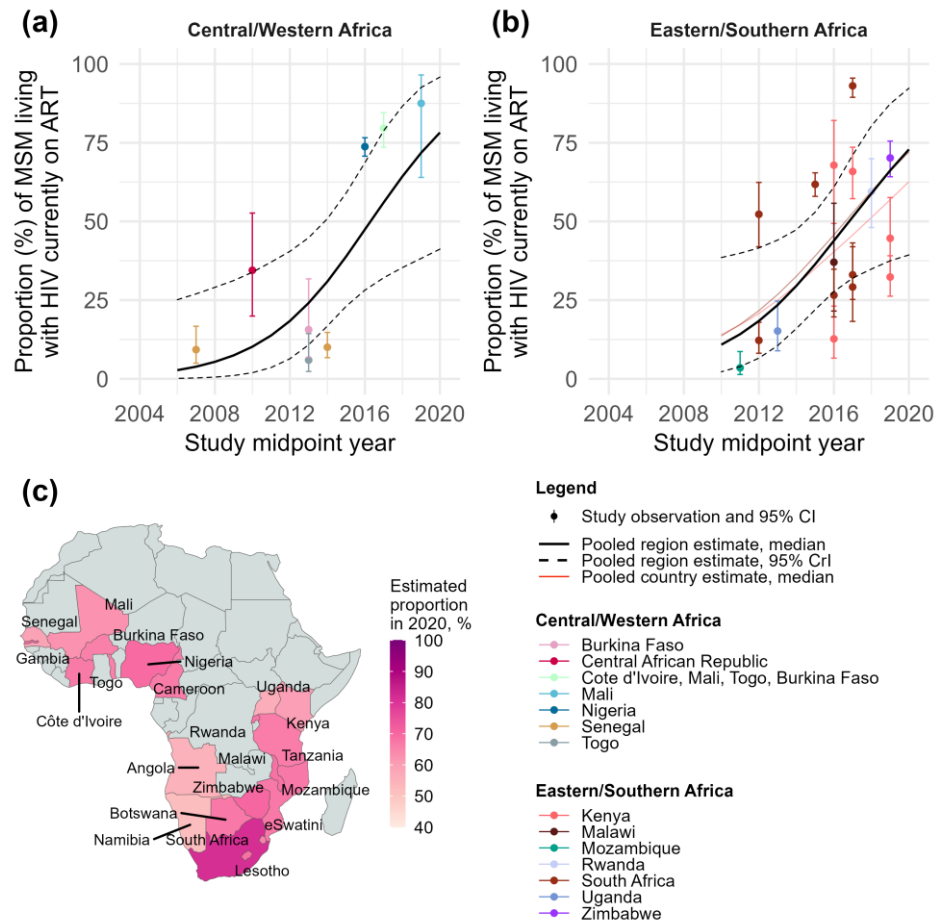


**Figure 3. Knowledge of status among men who have sex with men (MSM) living with HIV over time, by region and country of Africa.** Knowledge of status in (a) Central/Western Africa, (b) Eastern Africa, (c) Southern Africa, and (d) the estimated proportion of MSM living with HIV who know their status in 2020, by country. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points (see Figure S18 for individual country-level time trends and 95% CrI).

With the exception of current ART use, there were too few observations of the remaining engagement in care outcomes (e.g., ever or currently receiving non-ART care, retention in care in the past 12 months, ever ART use) to investigate time trends (Text S4, Figure S8-9).



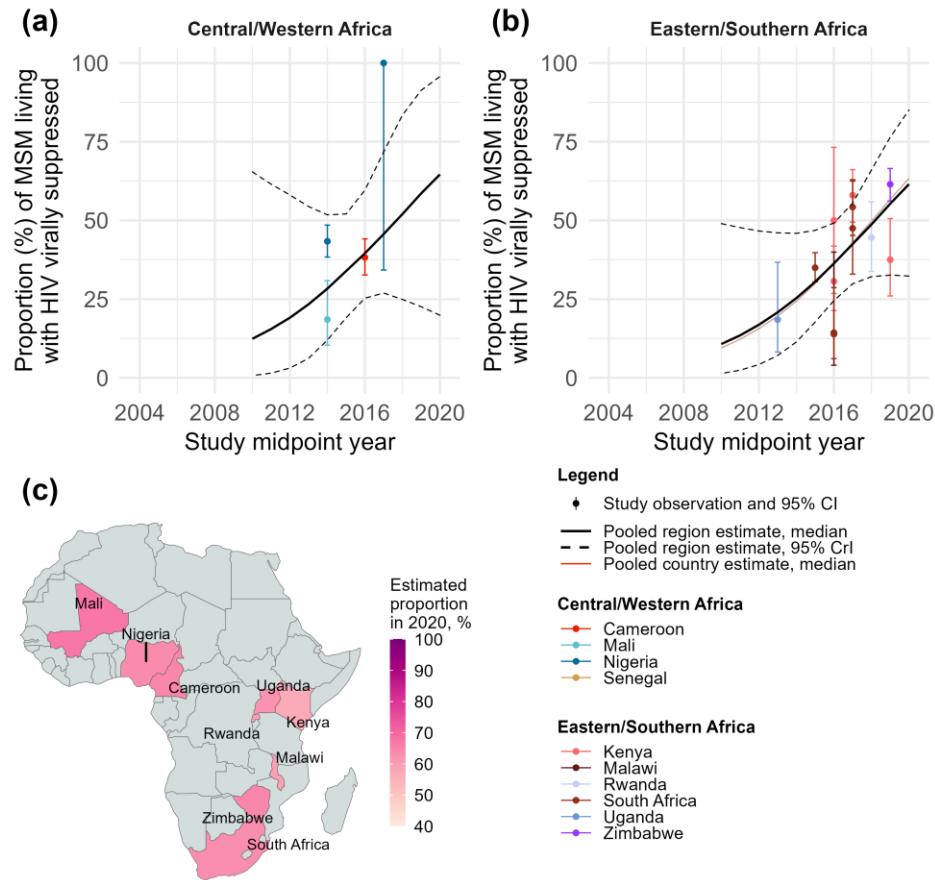
Among MSM living with HIV, we estimated that 75% (18-98%) of them would be on ART in 2020. Current ART use among MSM living with HIV increased from 10% (2-34%) in 2010 to 78% (41-96%) in 2020 in Central/Western Africa ( $OR_{year}=1.42$ , 1.08-1.95,  $N_o=8$ ), and from 11% (2-39%) in 2010 to 73% (39-92%) in 2020 in Eastern/Southern Africa ( $OR_{year}=1.36$ , 1.04-1.82,  $N_o=17$ ) (Figure 4, Table 2, Figure S10, S19). Time trends in current ART use among those aware were similar, albeit inconclusive, and in 2020 current ART use among diagnosed MSM was 92% (31-100%; Table 2, Figure S11, S20-21).



**Figure 4. Current antiretroviral therapy (ART) use among men who have sex with men (MSM) living with HIV over time, by region and country of Africa.** Current ART use among MSM living with HIV in (a) Central/Western Africa, (b) Eastern/Southern Africa, and (c) the estimated proportion of MSM living with HIV currently on ART in 2020, by country. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points (see Figure S19 for individual country-level time trends and 95% CrI).

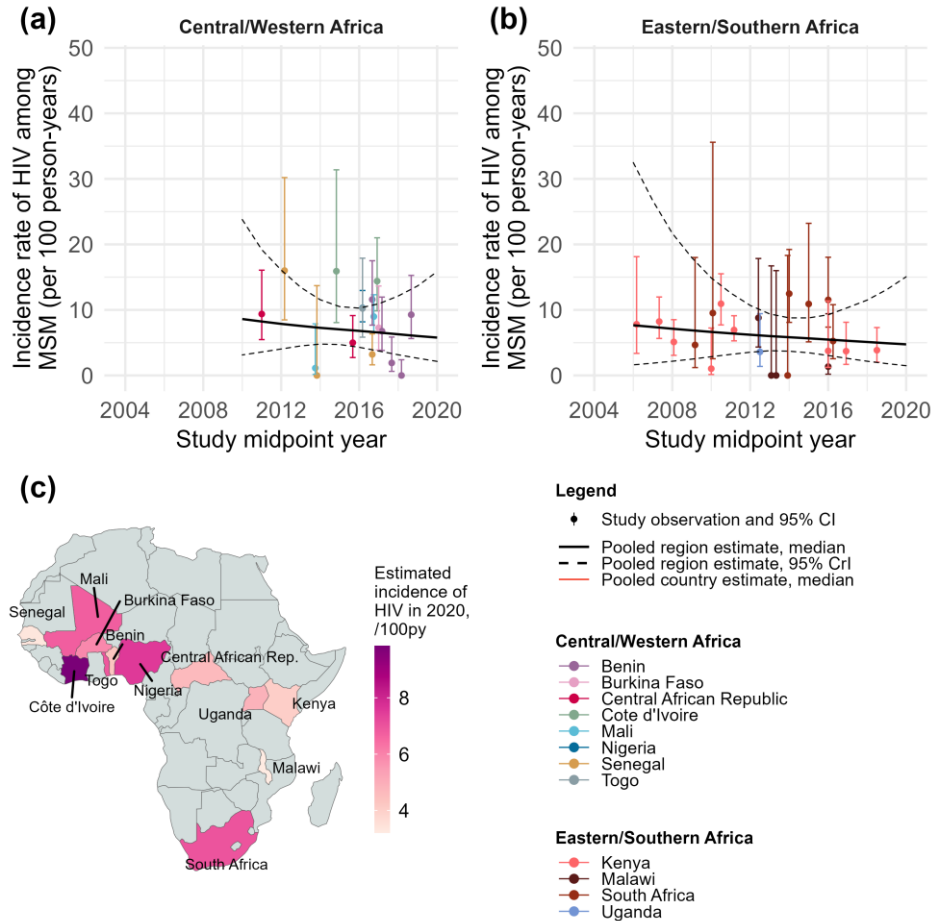
In 2020, we found that viral suppression was achieved among 62% (95%CrI 12-95%) of MSM living with HIV (Table 2). Time trends in viral suppression among MSM living with HIV suggested potential increases over time, from 11% (1-48%) in 2010 to 61% (32-84%) in 2020 in Eastern/Southern Africa ( $OR_{year}=1.29$ , 0.95-1.79,  $N_o=12$ ), although all credible intervals crossed

the null (Figure 5, Table 2, Figure S12, S22). Our 2020 viral suppression estimates were 78% (9-99%) among HIV aware MSM and 91% (24-100%) among MSM currently on ART (Table 2, Figure S13-14, S19, S23-25).



**Figure 5. Viral suppression among men who have sex with men (MSM) living with HIV over time, by region and country of Africa.** Viral suppression among MSM living with HIV in (a) Central/Western Africa, (b) Eastern/Southern Africa, and (c) the estimated proportion of MSM living with HIV virally suppressed in 2020, by country. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points (see Figure S22 for individual country-level time trends and 95% CrI).

In 2020, we estimated that HIV incidence among African MSM was 5.4 per 100 person years (95%CrI 0.9-33.9) and there was no conclusive evidence of a decline in HIV incidence among MSM in Africa over time since 2010 ( $IRR_{year}=0.97$ , 0.73-1.31,  $N_o=15$ ), or in any region (Central/Western Africa:  $IRR_{year}=0.97$ , 0.82-1.16,  $N_o=17$ ; Eastern/Southern Africa:  $IRR_{year}=0.97$ , 0.82-1.16,  $N_o=21$ ; Figure 6, Table 2, Figure S15, S26).



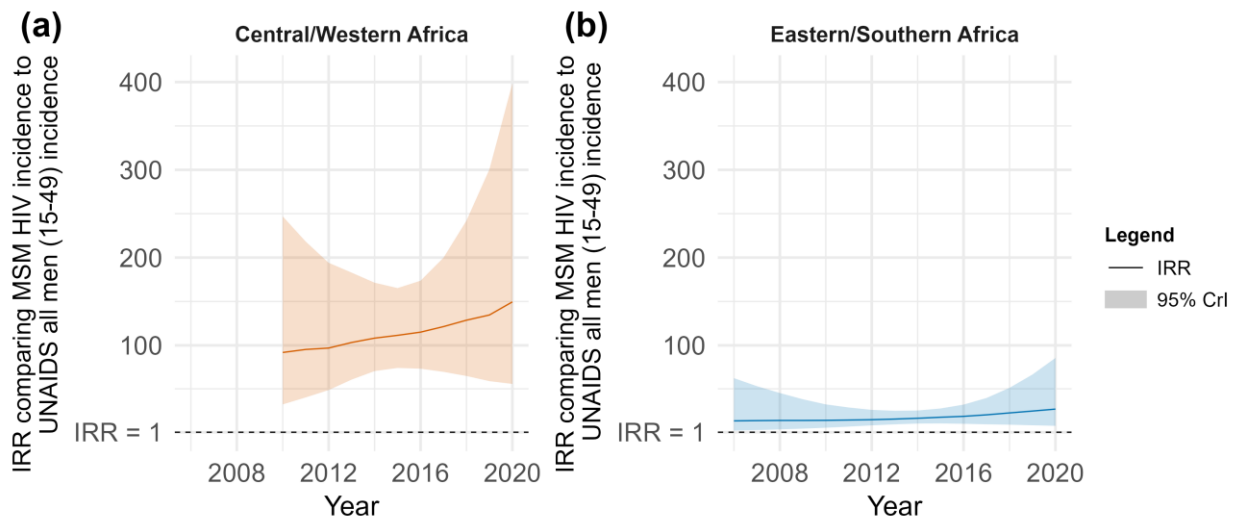
**Figure 6. HIV incidence among men who have sex with men (MSM) over time, by region and country of Africa.** (a) HIV incidence over time among MSM in Central/Western Africa, (b) Eastern/Southern Africa, and (c) the estimated incidence of HIV among MSM in 2020, by country, estimated using a Bayesian Poisson generalized linear mixed-effects model, with study-, country-, and region-level random effects. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level proportions and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level proportions for countries with at least 3 estimates from 3 different time points. Points represent available study observations and their 95% confidence intervals, coloured by country in which the study was conducted. The black solid and dotted lines represent the estimated region-level HIV incidence rate and 95% credible intervals (CrI), respectively. Coloured solid lines represent estimated country-level HIV incidence rates for countries with at least 3 estimates from 3 different time points (see Figure S26 for individual country-level time trends and 95% CrI).

### The HIV treatment cascade and HIV incidence among MSM compared with all men

Knowledge of status among MSM living with HIV between 2015 and 2020 were consistently lower than year-matched UNAIDS estimates among all men living with HIV aged 15+ in Eastern/Southern Africa, yielding a prevalence ratio (PR) of 0.74 (0.39-0.97) in 2020, but were

similar in Central/Western Africa (Figure S27a-b). Point estimates of the PR for current ART use and viral suppression varied in direction across region, but the uncertainty intervals were wide and crossed the null (Figure S27c-f).

Our estimates of HIV incidence among MSM were substantially higher than corresponding UNAIDS estimates among all men aged 15-49 (Figure 7). In 2020, UNAIDS reported an HIV incidence among men of 0.04% in Eastern/Southern Africa and 0.20% in Central/Western Africa. This entails that HIV incidence among MSM could be 27 times higher (95%CrI 8-86 times) than among all men in Eastern/Southern Africa, and 150 times higher (95%CrI 57-419) in Central/Western Africa.



**Figure 7. Incidence rate ratios (IRR) and 95% credible intervals (CrI) over time comparing our estimates of HIV incidence among men who have sex with men (MSM) with UNAIDS estimates among all men (aged 15-49), by region of Africa.** (a) Central/Western Africa, and (b) Eastern/Southern Africa. Solid lines correspond to medians and shaded areas to the 95% CrI.

### Study quality and risk of bias

Across all studies, risk of bias in reported outcomes was moderate ( $N_{\text{outcomes}}=185$ ; Table S3). Study outcomes with a higher risk of bias ( $N_{\text{outcomes}}=120$ ) were largely limited by non-representative sampling designs, selected study populations of MSM, and non-confidential interview methods. Funnel plots did not provide strong evidence of publication bias in study observations of HIV incidence, testing, and treatment cascade outcomes, and there was little difference between directly reported study observations and those calculated from available data (Figure S28).

### DISCUSSION

In this comprehensive systematic review and meta-regression study, we highlighted improvements in HIV testing and ART coverage over time among MSM in Africa. Nevertheless, 1 in 3 MSM living with HIV do not have a suppressed viral load. HIV incidence among MSM in Africa was close to 5 per 100 person-years in 2020, and there was no indication of a temporal

decline in new HIV acquisition between 2006 and 2020. Such HIV incidence rates among MSM are 27-150 times larger than corresponding rates among all men, highlighting the extreme disparities and exacerbated vulnerabilities to HIV acquisition and transmission among MSM in Africa.

HIV incidence among the overall population has steadily declined over the past decade, by 44% in Eastern/Southern Africa, and 43% in Central/Western Africa. This decline has mainly been attributed to ART scale-up and the resulting population-level viral suppression<sup>181</sup>. As this study suggests, HIV incidence declines among the overall population may not reflect HIV incidence trends among MSM. If fewer resources are allocated to prevention in response to decreasing incidence trends in the overall population, progress among key populations could be compromised<sup>182</sup>. This is especially salient in Central/Western Africa where our 2020 HIV incidence estimate among MSM was 150 times higher than among all men. Even in a hyperendemic context in Eastern/Southern Africa where MSM are estimated to have accounted for only 6% of new HIV acquisitions in 2020, incidence was 27 times higher<sup>1</sup>. In all regions, these disparities are worsening over time as incidence decreases among the general population, despite recent advances in biomedical prevention, including oral and injectable pre-exposure prophylaxis (PrEP), for which access currently remains very limited<sup>1,183,184</sup>. Studies suggest high willingness to use HIV prevention, including PrEP, among MSM in Africa and has potential population-level benefits, through network effects of preventing onward transmissions<sup>185-189</sup>. Yet, services are not available in many countries, or are too far away, too inconvenient, or not adapted to the needs of MSM<sup>190</sup>. These are compounded by economic barriers such as poverty that further limit access<sup>190,191</sup>. Resources to provide services are often limited, efficacious interventions may not be scalable, and services dedicated to MSM may not be appealing if men fear being identified as MSM<sup>190,192</sup>. This study highlights the need for combination HIV prevention, with elements of structural, behavioural, and biomedical interventions. Such an approach is considered the most desirable strategy for attracting and retaining MSM in care and prevention services to achieve reductions in HIV incidence<sup>190</sup>.

Understanding where losses to follow-up occur along the HIV treatment cascade is critical to developing appropriate interventions to reduce HIV transmission and incidence among MSM. We estimated that, in 2020, most MSM had ever tested for HIV (87%) and tested in the past year (88%), and that testing has generally increased over time, particularly in Central/Western Africa, and Eastern Africa, mirroring population-level increases in HIV testing<sup>193</sup>. Nevertheless, only 66% of MSM living with HIV in 2020 were aware of their status. Knowledge of status also remains lower among MSM than among all men living with HIV in Africa. However, knowledge of status may be underestimated since the majority of studies relied on self-reports, which are susceptible to underreporting<sup>194,195</sup>. This is particularly apparent when comparing our knowledge of status estimates with those from current ART coverage, which are roughly 10%-point higher. Going forward, biomarkers could be used to adjust self-reports, but this is only useful in settings where ART coverage is high. More generally, enabling environments are needed that encourage uptake of HIV testing, linkage to care, and disclosure of HIV status. Expanding community-led services, including involving peer-navigators to support MSM to access and remain in care, and increasing the use of alternative, decentralized HIV testing modalities such as HIV self-tests and virtual services could improve knowledge of status and linkage into care for MSM in Africa<sup>196</sup>.



Current ART use has increased over time to reach 78% and 73% of all MSM living with HIV in 2020 in Central/Western Africa and Eastern/Southern Africa, respectively. These coverage estimates are on par with those reported for all men, but slightly higher than those from a recent synthesis of MSM surveys that reported estimates of 52% and 69% in Central/Western Africa and Eastern/Southern Africa in 2021<sup>11</sup>, but the uncertainty intervals in both studies overlap. Nonetheless, viral suppression among all MSM living with HIV in Africa was lower, at 62%. Our estimates of ART use and viral suppression are lower than what is needed to achieve the 95-95-95 targets, which require that at least 90% of all MSM living with HIV are on ART, and 86% are virally suppressed. Failure to close these gaps leaves MSM vulnerable to ongoing transmission and continued HIV-related morbidity and mortality, undermining the strategy the end AIDS. Innovative drug delivery models, including peer-navigation and provision of ART outside of clinics, could help increase equitable access to first-line ART regimens and increase viral suppression among MSM<sup>197</sup>. Long-acting ART formulations, once availability increases, could also be important for overcoming some barriers to ART adherence.

Our results should be interpreted considering several limitations. First, although we did not exclude studies based on language, we used English and French search terms, which may have missed studies published in other languages. Second, most included studies used non-representative sampling designs, largely relying on convenience sampling, particularly in cohort studies that measured incidence, whilst RDS was common in cross-sectional studies. RDS could oversample young, urban, socially connected MSM, and miss older, non-gay identifying MSM, but can theoretically yield more representative estimates when adjusted for sampling design<sup>198</sup>. However, few of the included studies that used complex sampling designs (including RDS, cluster, and time-location sampling) provided adjusted estimates. Third, variable MSM definitions were applied to recruit participants, and most studies included some transgender women. Fourth, self-reported outcomes were often assessed in face-to-face interviews, which may be impacted by social desirability and recall biases. Increased use of confidential interview methods including audio computer-assisted self-interviews (ACASI) could improve accuracy<sup>199</sup>. Finally, there was high uncertainty in our MSM estimates over time, partly due to the limited number of available studies and heterogeneous observations. There were particularly few observations of engagement in care, ART use, and viral suppression among MSM with minimal increases since previous reviews, and few observations of any outcome from Central or Northern Africa<sup>6</sup>.

Strengths of this study include the substantial increase in the number of included studies compared to previous reviews, using data from 148 studies in 30 countries encompassing over 40,000 MSM, conducted from 2003-2020<sup>6,200,201</sup>. Importantly, we provide novel analyses and results of pooled HIV incidence among MSM over time in Africa. We pooled observations using mixed-effects meta-regression models within a Bayesian framework, which allowed us to borrow information across observations to produce estimates in settings with sparse data. We also calculated additional study estimates, minimizing publication bias.

## CONCLUSIONS

Despite continued increases in HIV testing among and engagement in the HIV treatment cascade among MSM living with HIV across settings, HIV incidence remains high among MSM across Africa and does not appear to be decreasing. Better combination interventions tailored to the primary HIV prevention needs of MSM that address the social, structural, and behavioural

factors that exacerbate their vulnerabilities to HIV will likely be important to increase access to ART and viral suppression and, ultimately, reduce disparities in HIV incidence.

### **Contributions**

JS, MC-B, MM-G, and JL conceptualized this review and planned the analysis. JS, NS, and LJ did the search and independently did all stages of screening. JS, NS, and LJ independently extracted data, and JS conducted all analyses. NS and KG double checked the data extraction. MM-G and MC-B checked the data analysis. JS, MM-G, and MC-B interpreted the results and conceptualized the first draft of the review. KM, NK, RM, MNN, and GMK made substantial contributions to the interpretation of the results and edited the manuscript. All authors read and approved the final version of the manuscript.

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