"Linkage to care" among people living with HIV – definition in the era of "universal test and treat" in a sub-Sahara African setting

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Summary

BACKGROUND: Prompt linkage to human immunodeficiency virus (HIV) care after diagnosis is of utmost importance for individual health and reduction of HIV transmission. Different definitions for "linkage to care" have challenged comparisons as a public health marker. Its meaning in the era of "universal test and treat" has transformed in all settings, but is most relevant in sub-Sahara Africa, where the burden of new HIV infection is still highest.

METHODS: For this narrative review on "linkage to care" definitions with a focus on sub-Saharan Africa, we searched PubMed/Medline between September and December 2020, restricted to the period 2000–2020 using Boolean operators: "HIV" AND ("linkage to care" OR "engagement in care") and screened for institutional definitions of "linkage to care". Additionally, as one example of a rural sub-Saharan African setting, we analysed linkage steps within the Chronic Diseases Clinic Ifakara (CDCI) and its associated Kilombero and Ulanga Antiretroviral Cohort (KIULARCO) in rural Tanzania between 1 January 2017 and 31 March 2019.

RESULTS: We analysed 81 articles that included "linkage to care" within different study settings and HIV organisations. Major differences in defining "linkage to care" exist, according to setting and location, patient populations and the timing of steps within the linkage process. We identified 16 different numerators and 10 denominators used to define linkage with time periods ranging from "same day as diagnosis" up to 12 months after diagnosis among 34 original articles from sub-Saharan Africa. At the CDCI, 1149/1671 (69%) newly diagnosed individuals were enrolled into care after diagnosis. Three months after enrolment into care, 94%, 86%, 85% and 71% of enrolled patients had a laboratory evaluation, a clinical evaluation, were initiated on treatment and had a first clinical follow-up visit after initiation of treatment, respectively.

DUSCUSSION: To address the inconsistency in defining "linkage to care" and in order to guarantee the comparability of "linkage to care" in the sub-Saharan Africa region, we support the definition from the European region with some adaptions. We suggest a priority list of care indicators if more than one care indicator is available for successful "linkage to care" in the era of "universal test and treat" for sub-Sahara Africa.

Background

The effectiveness of human immunodeficiency virus (HIV) testing, care and treatment programmes are jeopardised by the loss of patients at all levels of the HIV care continuum, and existing gaps have been well documented in systematic reviews and observational studies [1–3]. The highest loss of patients has been observed during the "linkage to care" step – which is enrolling the patient in care once tested positive for HIV [1–6]. Identifying people living with HIV / acquired immunodeficiency syndrome (AIDS) (PLWHA) and successfully linking them to care remains a key role in the HIV pandemic for both treatment of the individual and prevention of onward transmission [7]. "Linkage to care" is a key HIV indicator for public health monitoring, but it is challenging to evaluate it and its definition has changed in the era of "universal test and treat" [7–9]. The goal of this narrative review is to elaborate on the challenges, changes in and differences between definitions and provide guidance for the choice of a clinically meaningful definition for "linkage to care", with focus on a rural sub-Saharan African setting in the era of "universal test and treat". Additionally, we present results from the Kilombero and Ulanga Antiretroviral cohort (KIULARCO) in Tanzania.

Methods

Narrative review

We searched PubMed/Medline between September and December 2020, restricted to the period 2000–2020 and

articles written in English. We used the following search strategy with Boolean operators: "HIV" AND ("linkage to care" OR "engagement in care"). Our focus was on original articles, systematic reviews and meta-analyses. Several other search terms were applied and added to identify appropriate studies for specific questions, such as "care cascade", "care continuum", "sub-Sahara Africa" or "Tanzania". In addition, we also had access to an unpublished systematic review analysing the HIV care cascade from HIV diagnosis to viral suppression in sub-Saharan Africa [10]. Institutional websites such as the World Health Organization (WHO), the Joint United Nations Program on HIV/AIDS (UNAIDS) and the Center for Disease Control and Prevention (CDC) were screened for "linkage to care" definitions. Studies were eligible if they included definitions for "linkage to care" (including numerators, denominators and time restrictions) and presented "linkage to care" proportions. RM performed the review, entering results in a data extraction form to collect the following information from each eligible article: first author's name, publication year, country and setting where study was conducted, sample size, study design, numerator and denominator for "linkage to care", time period for prompt "linkage to care" and "linkage to care" proportions.

Analysis of KIULARCO data

The Chronic Diseases Clinic of Ifakara (CDCI) at the St Francis Referral Hospital in Tanzania was established in 2004 as the governmental HIV Care and Treatment Centre in the Kilombero and Ulanga districts in Tanzania. The CDCI provides HIV testing services for all patients seen in the hospital, and care and treatment for PLWHA according to government guidelines. Consenting patients are included in KIULARCO, a collaborative project of the SFRH, the Ifakara Health Institute (IHI), the Swiss Tropical and Public Health Institute, and the University Hospital Basel [11, 12]. Comprehensive data including clinical visits and prescriptions are captured electronically. We assessed the cascade from HIV testing to retention in care at 6 months among participants enrolled between 1 January 2017 and 31 March 2019, with follow up to the end of 2019. This time period was chosen because testing data were available only from 2017 onwards, and to avoid interruptions to normal care due to the COVID-19 pandemic. The steps assessed were: (i) proportion of persons testing HIV positive, (ii) proportion of PLWHA enrolled into KIULARCO, among those newly testing HIV positive, (iii) proportion of participants with laboratory evaluation within 7 days, and 1, 3, 6, and 9 months from enrolment into KIULARCO, (iv) proportion of participants with clinical evaluation within the same time periods, (v) proportion of participants with treatment initiation within the same time periods, (vi) proportion of participants with a clinical follow-up visit following treatment initiation within the same time periods. Results for step (ii) should be considered an approximation, because consent for data collection begins only at KIULARCO enrolment and HIV testing results are not consistently captured in the KIULARCO database. We defined newly diagnosed persons as those with date of diagnosis not before KIULARCO enrolment and not previously on treatment.

Results

Search results for the narrative review

We analysed 81 references, and a subset of 34 original articles from 10 sub-Saharan African countries were included for the assessment of "linkage to care" definitions and results (supplementary figure S1 in the appendix).

HIV care frameworks and the importance of timely "linkage to care"

To assess the success and challenges of the international collaborative HIV programmes in different countries over different time periods, tools were developed that incorporate key indicators to monitor the public health response to HIV [13–15]. Two major frameworks exist: (i) the HIV care continuum – also termed the HIV care cascade – formed in the United States of America in 2013 and outlining the five stages of HIV care through which PLWHA pass (being diagnosed with HIV, linked to care, received HIV medical care, retained in care, and achieved and maintained viral suppression) [6, 16–21], and (ii) the UNAIDS targets derived from the WHO strategic information guidelines in 2015, outlining three stages of HIV care (being diagnosed, being on treatment and being virally suppressed) [16, 22]. Both of these frameworks end with the main goal of HIV viral load suppression as optimal health outcome at both the individual and population levels [18, 19, 23, 24]. The UNAIDS used to work with the 90-90-90 targets, which were 90% of all PLWHA being tested, of those 90% being on treatment, and of those 90% being virally suppressed. After not reaching the goals set for 2020, the new targets for 2025 are even more ambitious, stepping up to 95% of the previous goals and adding further targets such as coverage of services for prevention of vertical transmission (fig. 1) [26].

The reporting of the individual steps of the frameworks allows evaluation of where attrition from care occurs and identifies gaps and opportunities for specific interventions to improve outcomes for PLWHA [6, 17, 24]. The steps are represented as a linear and unidirectional pathway [6]. However, literature shows that PLWHA often experience the care continuum in a more dynamic way, as they may skip stages, exit and re-enter the continuum temporarily or permanently, or regress back to earlier stages [16].

Recent literature identified the early step of "linkage to care" – from knowing of being HIV positive to accessing care – to be key in the cascade [16]. Linkage is a precursor for successful HIV treatment, viral suppression and optimal patient outcome, as well as preventing onward transmission [7, 9, 27–33]. In 2015, the WHO recommended a "universal test and treat" strategy for starting antiretroviral treatment ideally on the same day of a new HIV diagnosis – at the latest within 7 days after diagnosis [8, 15, 34, 35]. In the era of "universal test and treat", "linkage to care" as a public health parameter has changed. Successful "linkage to care" used to reflect acceptance of a positive test result with the first clinical visit, while the readiness to start treatment and first prescription of antiretroviral therapy (ART) could be at a later time point.

Differences in definitions of "linkage to care"

The 2015 strategic WHO guidelines defined "linkage to care" as "the duration of time starting with HIV diagnosis and ending with enrolment in HIV care or treatment", with few recommendations on linkage indicators and time periods for prompt linkage (table 1) [9, 22].

An expert panel co-funded by the European Commission (OptTEST, optimising testing and "linkage to care" for HIV across Europe project), defined "linkage to care" as

"patient entry into specialist HIV care after diagnosis, measured as the time between the HIV diagnosis date and either the first clinic attendance date, first CD4$^+$ count or viral load date, or HIV treatment start date, depending on data availability" (table 1) [9]. In addition to the WHO definition, this definition included (a) a list of care indicators if more than one linkage indicator were available, with the first clinic attendance date after diagnosis considered the gold-standard marker for successful "linkage to care",

Figure 1: Updated UNAIDS 95-95-95 targets for 2025; source: https://aidstargets2025.unaids.org [25]. Reprinted with permission from UN-AIDS.
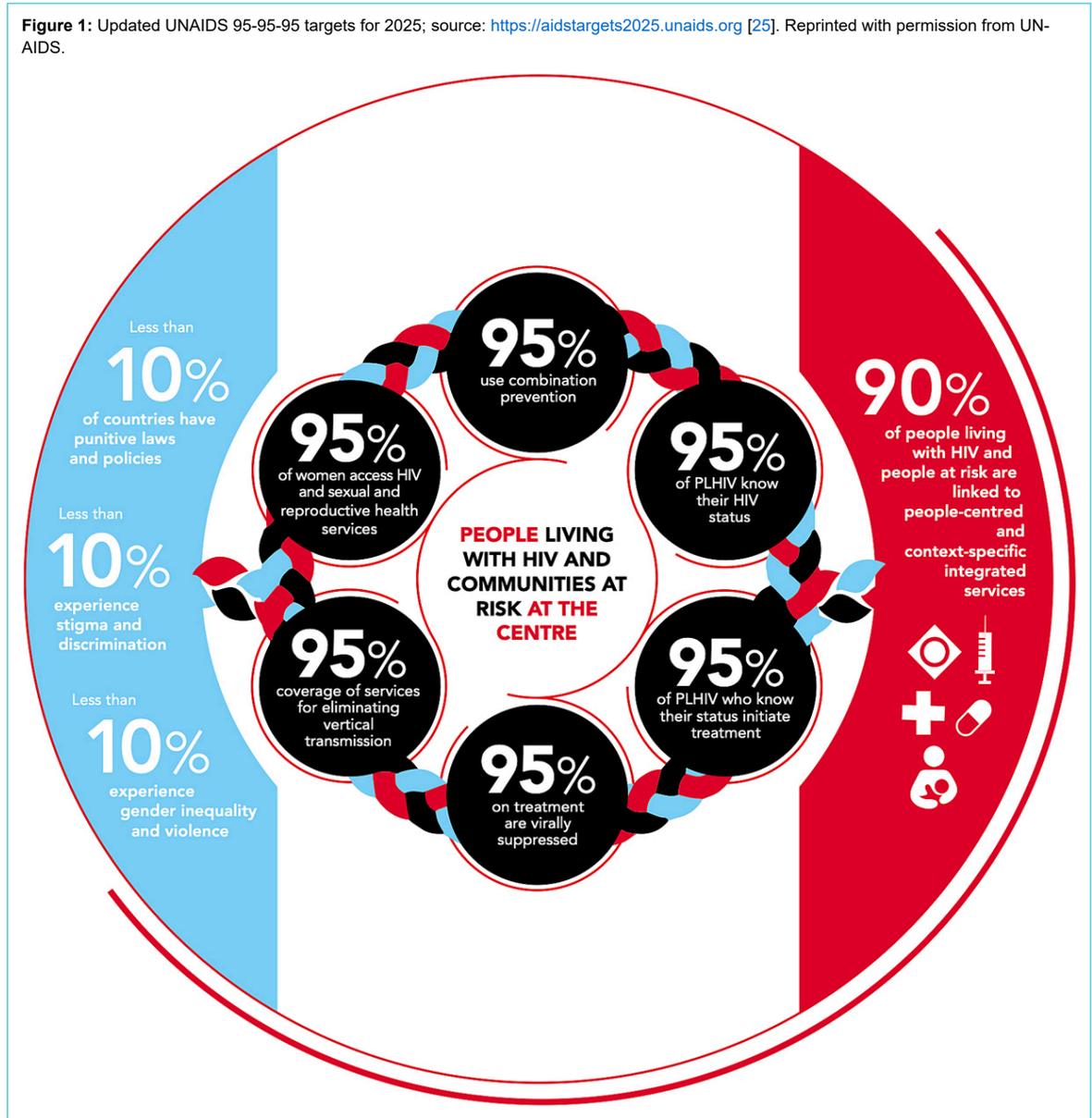
Table 1: Institutional definitions of "linkage to care".

Institution	Numerators for "linkage to care"				Time period after diagnosis
	Clinical visit	CD4$^+$ count recorded	Viral load recorded	Treatment initiation	
WHO Consolidated strategic information guidelines for HIV; 2015 [22]	Yes	No	No	Yes	None defined
Optimising testing and "linkage to care" for HIV across Europe project (OptTEST); 2018 [9]	Yes*	Yes*	Yes*	Yes*	Within 3 months
Monitoring Selected National HIV Prevention and Care Objectives by Using HIV Surveillance Data CDC (US); 2018 [36]	Yes	Yes	Yes	No	Within 1 month and 3 months

* Time to "linkage to care" defined as time between diagnosis date and (i) care attendance date (gold-standard marker), (ii) CD4$^+$ date, (iii) viral load date, and (iv) treatment initiation [9]

and (b) a time period for prompt "linkage to care", with 3 months after diagnosis as cut-off [9]. As this definition is less applicable to community-based testing, they supported the definition for community-based linkage as "entry into health care or follow-up by an HIV specialist or in an HIV-unit after a positive HIV test at a community testing facility" [9].

The Centers for Disease Control and Prevention (CDC) suggests monitoring "linkage to care" at 1 month and 3 months after HIV diagnosis by the documentation of an HIV viral load or $CD4^+$ cell count (table 1) [7, 21, 36].

Scientific evidence on "linkage to care" in sub-Saharan Africa

For assessment of "linkage to care" definitions, we included 34 articles across 10 countries in sub-Saharan Africa (table 2 and supplementary table S1 in the appendix). Included countries were: South Africa [6, 37–40, 49, 51, 55–59, 65]; Zambia [41]; Uganda [38, 42, 43, 52]; Kenya [43, 44, 61]; Malawi [45, 60, 68]; Nigeria [50]; Sierra Leone [46]; Tanzania [47, 53, 62, 66, 67]; Mozambique [63]; Lesotho [27]; Eswatini/Swaziland [48, 54, 64].

We identified 16 different numerators for the definition of "linkage to care", with some articles combining more than one care indicator to indicate successful linkage. The most commonly used numerator was a clinical visit. Other frequently used numerators were proof of registration at the clinic, treatment initiation and availability of laboratory results, such as $CD4^+$ count and viral load. Some articles used self-reported measures as linkage indicators, such as
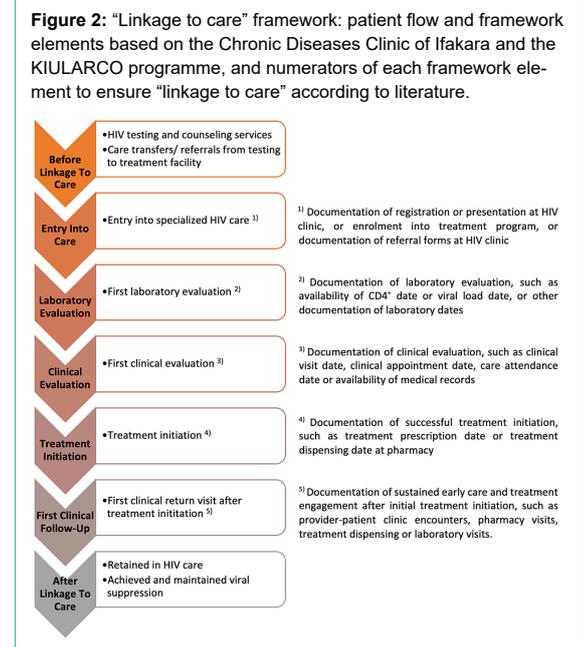
patient-reported clinical attendance or a HIV status disclosed by patients.

Out of the 10 denominators found for defining "linkage to care", the most frequently used were population denominators, but they also included some programme denominators. As an example, a new positive HIV test could be termed "tested HIV positive", "newly diagnosed with HIV" and "diagnosed with HIV". More importantly, the definition of "prompt" linkage could be the "same day as diagnosis" up to 12 months after diagnosis, and sometimes "ever linked to care" or "linked within study period" were used. The majority of studies defined prompt linkage as being linked within 3 months of HIV diagnosis. This is in line with the definitions used in other regions [10, 18, 24, 69–72]. With acknowledgment of the heterogeneity in definitions, "linkage to care" proportions among the identified articles ranged between 14–96% (n = 15) within 3 months and 15–96% (n = 34) that ever linked regardless of time period. When "linkage to care" was presented at multiple time intervals, linkage proportions improved with time from diagnosis [37–39, 41, 52, 69] and patients who linked to care in a facility tended to do so within 1 week of diagnosis, with the likelihood of patients linking to care increasing only marginally thereafter [43, 52].

We propose a "linkage to care" framework for a sub-Saharan African setting, based on our findings from the literature and our experience in the CDCI and KIULARCO (fig. 2). It includes steps as defined in the literature, combined with our knowledge of the functioning of the CDCI. Therefore, this cascade may need adapting for other settings, such as amending the order of the steps or even omitting steps completely.

"Linkage to care" proportions in different regions of the world

Linkage proportions from Western countries, irrespective of which linkage indicator was used, have been relatively high with studies reporting pooled estimates of 85% for the European region [69], 80–88% in the United States of

Table 2: "Linkage to care" definitions in literature from sub-Saharan Africa: summary of numerators, denominators and time periods.

Numerator for "linkage to care" definition
Evidence of medical care/ clinical records
– Clinic appointment/visit [6, 37–48]
– Accessed HIV care [49]
– Enrolled in care [50]
– Receiving home-based care [51]
– Registration/presentation in clinic [6, 27, 52–54]
– $CD4^+$ cell count [6, 51, 55–60]
– Viral load measurement [6, 51]
– Antiretroviral therapy (ART) start/date [6, 41, 48, 50, 51]
– Treatment of opportunistic infections [51]
– Medical records [61–64]
Self-reported measures
– Self-reported clinical attendance [65]
– Referral form [66, 67]
– Disclosed positive results [68]
Denominator for "linkage to care" definition
Population denominator
– Tested HIV positive [27, 37, 43, 47, 48, 56, 58, 59]
– Aware of HIV status [38]
– Diagnosed with HIV [6, 39, 64–66]
– Newly diagnosed with HIV [42, 46, 49, 50, 52, 53, 60, 62, 67]
– HIV positive, not on antiretroviral therapy, referred to clinic [41]
– HIV infected [40]
– HIV positive individuals/cases [44, 45, 54, 63]
– Self-reported HIV positive/diagnosis [57, 61]
Programme denominator
– HIV positive participants [51, 68]
– Newly diagnosed HIV positive participants [55]
Time period for prompt "linkage to care"
– "Same day as diagnosis" [52]
– 7 days [43, 48, 52]
– 1 month [37–40, 52, 67]
– 2 months [55]
– 3 months [27, 38–42, 49, 50, 52, 56, 58, 62, 64, 65, 67]
– 6 months [37–39, 41, 47, 53, 54, 57, 59, 60]
– 12 months [37, 38, 41, 43, 46, 64, 68]
– "linked within study period" / "ever linked to care" [6, 44, 45, 51, 58, 61, 63, 64, 66]

Figure 2: "Linkage to care" framework: patient flow and framework elements based on the Chronic Diseases Clinic of Ifakara and the KIULARCO programme, and numerators of each framework element to ensure "linkage to care" according to literature.

America [36, 73, 74], 73% for Canada and 90% in Australia [74]. In low-income countries the linkage proportions were shown to be appreciably lower [16, 75, 76] and poor linkage is particularly pronounced in sub-Saharan Africa, the world region most heavily affected by the global HIV epidemic [2, 47, 77]. The overall "linkage to care" was reported to be 59% in sub-Sahara Africa in 2011 [78], whereas more recent systematic reviews reported wide ranges of linkage proportions after different testing settings, such as 8–99%, 10–96% and 55–61% for home-based testing and counselling programs, community-based testing, and facility-based testing, respectively [71, 72, 79]. Literature from Tanzania revealed linkage proportions ranging between 24% and 91% [51, 54, 75, 79, 80]. The ranges of linkage proportions differ greatly and reflect a considerable lack of standardisation and consistency in defining "linkage to care", the use of low-quality methodologies, the little consensus across countries and also generally the different healthcare settings and resources available across sub-Saharan Africa. Barriers affecting entry into care in rural settings are described to be multifactorial and include a higher immune status and a patient's feeling of being physically healthy, rigid clinic policies, disrespectful treatment from service providers, stockouts of supplies, stigma and discrimination, alternate healing systems, distance to health facilities and poverty [37, 39, 49, 64, 80].

Analysis of "linkage to care" within KIULARCO

During the study period, 25,793 individuals were tested for HIV, of whom 1,671 (6%) tested positive. Excluding individuals who were diagnosed or started treatment before enrolment into KIULARCO, 1149 persons were enrolled into KIULARCO during this time (69% of those who tested positive). Usually, the enrolment is on the same day as testing. However, we could not ascertain this because of

a lack of individual patient data before enrolment. Among the 1149 newly diagnosed patients enrolled into KIULARCO, 92% (n = 1054), 80% (n = 917) and 68% (n = 779) had a laboratory evaluation, clinical evaluation and initiated treatment within their first week after enrolment, respectively (fig. 3).

The proportion of participants with a laboratory evaluation remained fairly stable thereafter, even up to 9 months following enrolment. The proportion of participants with a clinical evaluation increased slightly to 84% by 1 month, and further to 88% by 6 months. The proportion of participants who initiated treatment increased substantially to 82% by 1 month and only slightly more to 86% by 9 months. By 3 months, 71% of participants had had a clinical visit following treatment initiation, and this proportion remained stable up to 9 months.

Discussion

Challenges with the current "linkage to care" definitions have been addressed by many authors. Researchers have highlighted the considerable lack of standardisation and consistency in defining linkage, making it almost impossible to synthesise findings and compare estimates of cascade stages [6, 10, 17, 23, 24, 69, 71]. The lack of consensus is partly a consequence of different "linkage to care" processes across health systems and care settings [18, 24] and an over-simplification of "linkage to care" into a single step. Relatedly, there is little consent on what time period should be used to determine prompt "linkage to care".

Although the concept of "universal test and treat" implies that all steps from testing to treatment initiation happen simultaneously and steps such as pre-ART and pre-ART care became redundant, some authors have suggested a pragmatic operational framework for detailing the "linkage to care" process [8, 34]. Most care attrition occurs before pa-

Figure 3: Steps of the "linkage to care" process in 1149 newly tested individuals enrolled into KIULARCO [1].

	Time period from enrolment into specialized HIV care [1]	≤ 7 days	≤ 1 month	≤ 3 months	≤ 6 months	≤ 9 months
Entry Into Care						
Laboratory Evaluation	First laboratory evaluation [2]	1054 (92%)	1069 (93%)	1079 (94%)	1092 (95%)	1094 (95%)
Clinical Evaluation	First clinical evaluation [3]	917 (80%)	970 (84%)	986 (86%)	1006 (88%)	1008 (88%)
Treatment Initiation	Treatment initiation [4]	779 (68%)	938 (82%)	980 (85%)	989 (86%)	990 (86%)
First Clinical Follow-Up	First clinical return visit after treatment initiation [5]	37 (3%)	688 (60%)	810 (71%)	843 (73%)	850 (74%)

[1] 'Enrolment into specialized HIV care' is defined by enrolment of newly diagnosed and consenting individuals into KIULARCO, and excludes those indicated as previously diagnosed or on treatment before enrolment
[2] 'First laboratory evaluation' is defined by having a laboratory result form with sampling date within the given time period following enrolment
→ corresponding to 'CD4 count recorded' according to OptTEST and CDC
[3] 'First clinical evaluation' is defined by having a clinical visit with date within the given time period following enrolment
→ corresponding to 'Clinical visit' according to WHO, OptTEST and CDC
[4] 'Treatment initiation' is defined by initiating ART within the given time period following enrolment
→ corresponding to 'Treatment initiation' according to WHO and OptTEST
[5] 'First clinical return visit after treatment initiation' is defined by having a clinical visit with date after ART initiation and within the given time period following enrolment

tients even start treatment [2, 27, 47, 78, 81, 82]. Attrition between first ART prescription and the first clinical follow-up visit can range from 15% to over 30% [52, 56, 83, 84], raising the question of whether these newly diagnosed patients were ever truly linked to care [34]. Therefore, some authors have recently proposed to include a first follow-up visit after treatment initiation in the definition of linkage [34].

For the sub-Saharan African region, we support in general the definition from OptTEST defining "linkage to care" as "patient entry into specialist HIV care after diagnosis, measured as the time between the HIV diagnosis date and either the first clinic attendance date, first CD4$^+$ count or viral load date, or HIV treatment start date, depending on data availability" [9] within a time period of 3 months after diagnosis. The advantage of this definition is that it includes (i) a comprehensive list of care indicators and priority of indicators if more than one linkage indicator is available, and (ii) a time period to define prompt "linkage to care". Further, use of the same definition paves the way to consistency in estimates across countries. We support the time period of 3 months for prompt linkage, and not shorter, as opportunistic infections are more common in people living with HIV in sub-Sahara Africa and treatment initiation has to be delayed in cases with tuberculosis or cryptococcal meningitis. However, in contrast to OptTEST and the CDC, we suggest treatment initiation to be the gold-standard marker for successful "linkage to care" in the era of "universal test and treat". This is supported by our narrative review and results from KIULARCO. HIV treatment is the cornerstone of the "test and treat" strategy and within the "linkage to care" framework. If more than one HIV care indicator is captured within a facility, then we agree with OptTEST that the following indicators could be used, but suggest using the order according to figure 2: (i) treatment initiation, (ii) clinical evaluation, (iii) laboratory evaluation, and (iv) entry into care. The order of this priority was chosen to capture linkage with the least attrition from care, as attrition increases with each step throughout the linkage framework, as shown on the basis of the patient-flow we have in the CDCI and KIULARCO. The framework and definition currently apply to facility-based testing only and community-based testing needs to be addressed separately. Interestingly, a first clinical follow-up at the HIV clinic after community-based testing and/or treatment initiation does sound like a sensible definition for both community- and facility-based settings, and there could be an argument for basing the linkage definition on that. We generally support a paradigm shift to move towards using a first clinical follow-up visit after treatment initiation as numerator in the definition of "linkage to care" as it most accurately reflects true "linkage to care". We have to appreciate and accept that different clinics and care settings across sub-Sahara Africa, and across the globe, exist and not the same "linkage to care" indicators are available. Therefore, with regard to those differences, it is challenging to propose one unified definition for "linkage to care".

Limitations

This research is subject to some limitations. First, we performed a narrative review. Although we applied some systematic selection criteria, it is not a systematic review and may result in selection bias of the studies included and therefore bias in our conclusions. Second, our identification of newly diagnosed persons enrolled in KIULARCO may have missed some patients who were previously diagnosed (owing to unreported previous date of diagnosis or treatment) and therefore in particular we may have overestimated the proportion of newly diagnosed persons who were enrolled. Conversely, some participants may have registered at the CDCI but not enrolled into KIULARCO, and therefore the number of newly diagnosed persons enrolled into KIULARCO may be an underestimate for the number of newly diagnosed persons who linked to care.

Conclusion

"Linkage to care" is an early key element within the HIV care cascade that affects future steps within the cascade, yet there is much inconsistency and debate in defining this important public health marker. There is an urgent need for standardisation of methods, definitions and data collection approaches to accurately track progress towards control over the HIV epidemic and to achieve the updated 95-95-95 target by 2025. We have proposed a definition for this important public health measure that we consider appropriate for the sub-Sahara Africa region in the context of "universal test and treat" and that appreciates the new role of "linkage to care" in the HIV care frameworks.

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Appendix

Analyzed references for narrative review: N= 81 [1]
- Institutional/Organizational position papers: N= 10
    - World Health Organization: N=3
    - Centers for Disease Control and Prevention/ White House Government: N= 4
    - Joint United Nations Programme on HIV/AIDS: N=3
- Systematic reviews: N= 12
    - For sub-Saharan Africa region only: N=7
    - Including sub-Saharan Africa region: N=3
    - For non-sub-Saharan Africa region: N=2
- Original articles: 59
    - For sub-Saharan Africa region: N= 44
    - Non-sub-Saharan Africa region: N=15

Included articles to analyze numerators, denominators and time periods for prompt linkage to care in sub-Saharan Africa [2]
- Original articles: N=34

[1] We searched PubMed/MEDLINE in November 2020, restricted to the period 2000-2020 and articles written in English. We used the following search strategy with Boolean operators: "HIV" AND ("linkage to care" OR "engagement in care"). Several other search terms were applied and added to identify appropriate studies for specific questions, such as "care cascade", "care continuum", "sub-Sahara Africa" or "Tanzania". In addition, institutional websites were screened for 'linkage to care' definitions.
[2] For the analysis on defining 'linkage to care' in sub-Saharan Africa, studies were eligible if they included definitions for 'linkage to care' (including numerators, denominators, and time restrictions) and presented 'linkage to care' proportions.
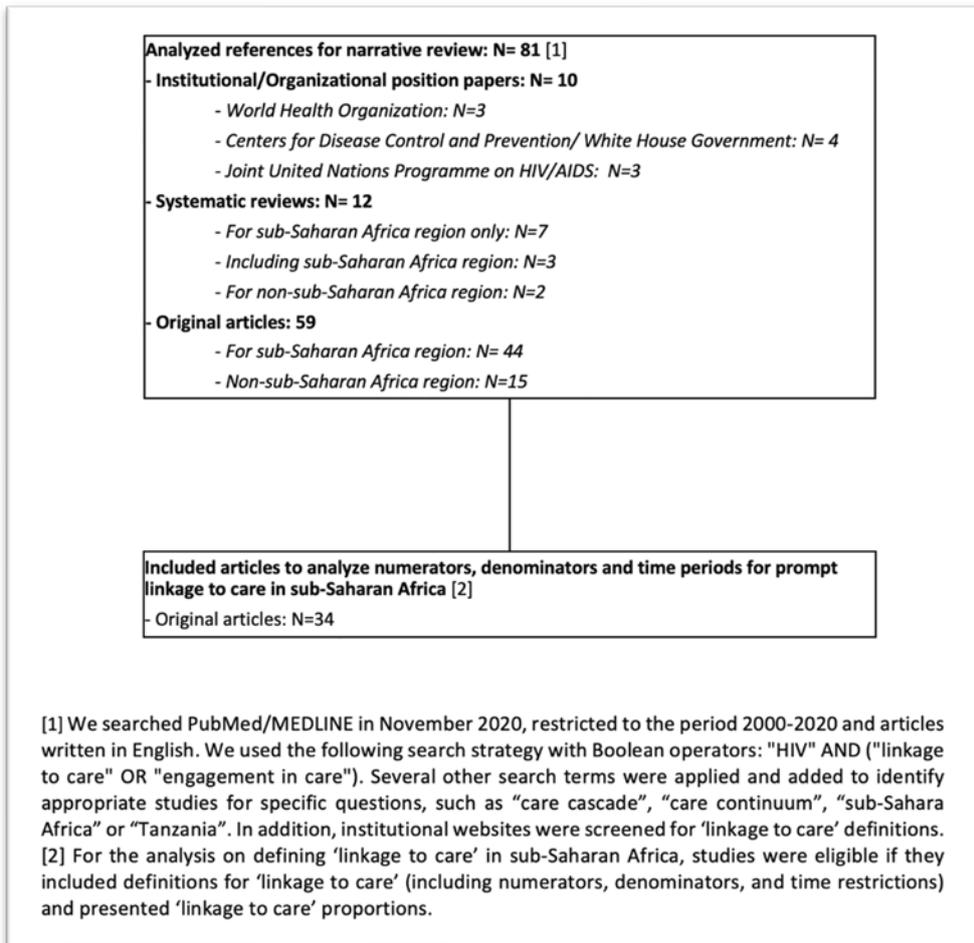
Figure S1: Search results for the narrative review.

Table S1: Extraction form: studies extracted for narrative review of linkage to HIV care in sub-Saharan Africa.

Author, Year	Study design	Country	Analysis period	Testing	Denominator Sample size	Numerator	"Linkage to care" rates at time after diagnosis						
							Day 0	1 week	1 month	3 months	6 months	12 months	Ever (no time defined)
ANRS12249 [TasP], Iwuji CC et al., 2016 [37]	Interventional	South Africa	2012–2014	Community	HIV pos. test n = 2569 adults	First clinic visit			(36.5%*) 37.1%†		(47.4%*) 47.6%†	(63.6%*) 62.6%†	
HPTN071 [PopART], Hayes R et al, 2017 [41]	Interventional	Zambia	2013–2015	Community	HIV pos., not on ART, referred to clinic n = 6197 adults	In care and on ART				32%†	42%†	53%†	
Barnabas RV et al., 2014 [38]	Interventional	South Africa Uganda	2011–2013	Community	Aware of HIV status n = 381 adults	Clinic visit			57%	86%	97%	96%	
Govindasamy D et al., 2013 [39]	Observational	South Africa	2010–2011	Community	HIV diagnosis (dependent on CD4+ count) n = 276 adults	Clinic visit			37.5%	53.0%	53.1%		
Boeke CE et al., 2018 [52]	Observational	Uganda	2015–2016	Facility	Newly diagnosed at facility n = 928 patients	Register for pre-ART or ART care at the facility	29.1%	46.6%	53.0%	56.6%			
Van Rooyen H et al., 2013 [40]	Interventional	South Africa	2011–2012	Community	HIV infected (known status, newly diagnosed) n = 201	Clinic visit			57%	96%			
Grobler A et al., 2017 [51]	Cross-sectional survey	South Africa	2014–2015	Community survey	HIV positive participants n = 51970	Receiving at least one of home-based care, a CD4+ cell count, viral-load testing, and ART or treatment of opportunistic infections							96%
Maman D et al., 2015 [44]	Population survey	Kenya	2012	Community survey	HIV positive individuals n = 1457	Medical contact for HIV care after positive test							56.2%

						"Linkage to care" rates at time after diagnosis							
Author, Year	Study design	Country	Analysis period	Testing	Denominator Sample size	Numerator	Day 0	1 week	1 month	3 months	6 months	12 months	Ever (no time defined)
Maman D et al., 2016 [55]	Population survey	Malawi	2013	Community survey	HIV positive individuals n = 1174	Medical contact for HIV care after positive test							74.2%
Chamie G et al., 2012 [42]	Interventional	Uganda	2011	Community	Newly HIV diagnosed n = 82 adults	Clinic visit after intervention				78%			
Haber N et al., 2017 [6]	Longitudinal Population based analysis	South Africa	2006–2011	Population	Diagnosed with HIV n = 5205 patients	Date of first recorded HIV clinic visit, registration at an HIV clinic, clinical CD4+ cell count, viral load count, or ART initiation							45%
Govindasamy D et al., 2011 [49]	Observational	South Africa	2010	Community	Newly diagnosed with HIV n = 77 adults	Accessed HIV care at a public healthcare facility at least once after testing				52.5%			
Losina E et al., 2010 [55]	Observational	South Africa	2006–2007	Facility	Newly diagnosed HIV-infected participants n = 454 adults	CD4+ count				* 2 mo. 54.6%			
Aliyu MH et al., 2013 [50]	Observational	Nigeria	2009–2011	Population	Newly diagnosed patients n = 1174 adults	Enrolled in care / initiated on ART				74%			
Choko AT et al., 2015 [68]	Prospective cohort within a cluster RCT	Malawi	2012	Community	HIV positive participants n = 1257 adults	Disclosed positive results to counsellors						56.3%	
Clouse K et. al., 2013 [56]	Observational	South Africa	2010	Facility	Testing HIV-positive	CD41+ staging within 3 months				69.8%			

Author, Year	Study design	Country	Analysis period	Testing	Denominator Sample size	Numerator	"Linkage to care" rates at time after diagnosis						
							Day 0	1 week	1 month	3 months	6 months	12 months	Ever (no time defined)
du Toit E et al, 2014 [57]	Cross-sectional survey	South Africa	2010	Community	Self-reported HIV positive n = 579	CD4+ Count					43%		
Fox MP et al. 2014 [58]	Observational	South Africa	2010–2012	Facility	Testing HIV positive n = 238	CD4+ Count				38.7%			47.4%
Kelly JD et al, 2016 [46]	Observational	Sierra Leone	2011–2012	Facility	Newly diagnosed with HIV n = 338	Clinical appointment						75.4%	
Kranzer K et al., 2010 [59]	Observational	South Africa	2004–2009	Facility	Individuals testing HIV positive n = 988	CD4+ count					62.6%		
MacPherson P et al., 2012 [60]	Observational	Malawi	2011	Facility	Newly diagnosed HIV positive adults n = 153	CD4+ count					52.9%		
Reddy EA et al., 2016 [47]	Observational	Tanzania	2008–2009	Facility (1) and community (3)	Tested positive for HIV n = 240	Clinic visit					70.4%		
Harklerode R et al., 2019 [66]	Observational	Tanzania	2017	Facility	Diagnosed with HIV n = 932	Referral form or probabilistic matching							73.1% (during study period)
Sanga ES et al., 2017 [53]	Mixed-method	Tanzania	2014–2015	Facility and community	Newly diagnosed HIV-positive adults n = 793	Reported to a CTC, completed the registration process and provided with a CTC registration number and clinic card.					78%		

							"Linkage to care" rates at time after diagnosis						
Author, Year	Study design	Country	Analysis period	Testing	Denominator Sample size	Numerator	Day 0	1 week	1 month	3 months	6 months	12 months	Ever (no time defined)
Rentsch CT et al., 2018 [62],	Observational	Tanzania	2014–2017	Facility and community	Newly diagnosed n = 411	Record matching				23.8%			
Kayabu DE et al., 2018 [67]	Cross-sectional study	Tanzania	2010–2014	Facility	newly diagnosed PLHIV n = 16,041	Referral form			82.9–85.3%	91%			
Courtenay-Quirk C et al., 2019 [63]	Mixed-method	Mozambique	2014	Facility	HIV-positive cases n = 248	Record matching							67%
Meehan SA et al., 2018 [65]	Observational	South Africa	2008–2012	Community	Diagnosed with HIV n = 5929	self-reported clinic attendance				63.1%			
CASCADE Trial Labhardt ND et al, 2018 [27]	Interventional	Lesotho	2016–2017	Community	Tested HIV positive and ART naive	Presenting at the health facility				68.6%[†] 43.1%[*]			
SEARCH Trial, Ayieko J. et al., 2019 [43]	Interventional	Kenya Uganda	2013–2014	Community	Tested HIV positive n = 2051	Clinic visit		49.7%				73.4%	
MacKellar D et al., 2018 [48]	Interventional	Swaziland/Eswatini	2015–2017	Community	Tested HIV positive n = 651	Clinical visit, ART dates		98%					
Parker LA et al., 2015 [67]	Observational	Swaziland/Eswatini	2013	Community	HIV positive individuals n = 398	Registration at HIV clinic					34%		

							"Linkage to care" rates at time after diagnosis						
Author, Year	Study design	Country	Analysis period	Testing	Denominator Sample size	Numerator	Day 0	1 week	1 month	3 months	6 months	12 months	Ever (no time defined)
MacKellar DA et al., 2016 [64],	Observational	Swaziland/Eswatini	2013–2014	Community	HIV diagnosed n = 1105	Medical chart, record matching				14.0%		24.3%	37.0%
Genberg BL et al. 2015 [54]	Observational	Western Kenya	2014	Community (home-based testing)	Self-reported HIV diagnosis n = 1360	Electronic medical records							15%

ART = antiretroviral therapy; CTC = community based therapeutic care programme; PLHIV = people living with HIV/AIDS; RCT = randomised controlled trial
* Control, † intervention