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Assessment of Neurocognitive Deficits in People Living with HIV in Sub Saharan Africa: A Systematic Review

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Abstract

Objective: People living with HIV (PLWH) are at risk for HIV-Associated Neurocognitive Disorders (HAND)/ Neurocognitive Impairment (NCI). HIV prevalence in Sub-Saharan Africa (SSA) is high, but neuropsychological screening and testing for NCI among HIV-infected individuals is not done frequently. This systematic review aims to establish how NCI among HIV-infected individuals is being assessed in SSA, if and how the tests are adapted, if norms exist and identify personnel who administer them.

Method: We searched PubMed, Medline, EBSCO, PsycINFO, and Web of Science. Two reviewers screened the articles for inclusion and risk of bias. We included studies from SSA with a comprehensive neuropsychological assessment battery.

Results: We retrieved 212 articles and 22 articles met inclusion criteria. The most commonly used tests were the Color Trails Test 1, Color Trails Test 2, and the WAIS III Digit Symbol Test. Some tests were translated into French (Cameroon), Luganda (Uganda), Chichewa (Malawi), isiXhosa (South Africa) and Afrikaans (South Africa). Some verbal learning tests were adapted to reflect culturally appropriate language. Test administrators were either non-specialised personnel supervised by clinical neuropsychologists or clinical psychologists.

Conclusion: Overall, the tests used are similar to the tests being used globally to assess NCI among HIV-infected individuals and there is a general consistency across countries. However, there is generally a lack of norms for the tests and the process of adaptation is not always well described. Future research should establish whether these tests measure neuropsychological constructs as successfully as they do in western populations where the tests were developed.

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Keywords

HIV; neurocognitive disorders; Africa; screening; assessment

Introduction

Of the 36.7 million people infected with HIV, 25.8 million live in Sub-Saharan Africa (SSA) (World Health Organization, 2016). Many people living with HIV/AIDS (PLWHA) are affected by HIV-associated neurocognitive impairment (NCI), also referred to as HIV-associated neurocognitive disorders (HAND) (Heaton et al., 2010) and in SSA the prevalence is as high as 70% (Habib et al., 2013; Kelly et al., 2014). HIV enters the brain early in infection (Marban et al., 2016; Zayyad & Spudich, 2015) and can result in infected macrophages, microglia and astrocytes (Marban et al., 2016) that may lead to neurocognitive impairment. HAND affects several neurocognitive domains – i) attention, ii) memory, iii) learning, iv) motor functioning, v) processing speed, vi) verbal fluency, and vii) executive functioning (Woods, Moore, Weber, & Grant, 2009) and has significant medical and functional consequences (Gorman, Foley, Ettenhofer, Hinkin, & van Gorp, 2009). It is associated with early mortality (Ku et al., 2014) and impacts activities of daily living, employability (Foley, Ettenhofer, Wright, & Hinkin, 2008), internet based tasks such as online banking and shopping (Woods et al., 2017), medication adherence (Hinkin et al., 2002), driving (Marcotte et al., 1999, 2004) and is linked to HIV transmission risk behaviour (Anand, Springer, Copenhaver, & Altice, 2010).

Identifying PLWHA who have NCI is essential to providing effective treatment (The Mind Exchange Working Group et al., 2013). The first step in addressing this need is screening for NCI among HIV-infected individuals in primary health care clinics followed by a confirmatory diagnosis using a comprehensive neuropsychological test battery and clinical investigation. However, it is important to note that HAND, as opposed to NCI, is a diagnosis by exclusion and cannot be determined from a neuropsychological test alone. In addition to assessing functional abilities other confounding conditions need to be excluded before a diagnosis of HAND can be made (Antinori et al., 2007; The Mind Exchange Working Group et al., 2013). With the greatest burden of HIV and likely millions upon millions of cases of NCI among HIV-infected individuals SSA is limited in its capacity to detect, diagnose and manage it. This is due to inadequate specialised personnel and issues around measurement.

A comprehensive neuropsychological (NP) assessment by a neuropsychologist who administers, scores and interprets the test results is the gold-standard for diagnosing HAND (Robertson, Liner, & Heaton, 2009; Sanmarti et al., 2014). A comprehensive NP assessment for HAND should assess an individual across seven cognitive domains (Antinori et al., 2007; Woods et al., 2009). However, this is not possible in many SSA settings. Trained experts are often unavailable in these resource limited settings, NP tests and assessments are expensive and thus unaffordable, and assessments are lengthy to administer in overburdened clinic settings (Moore et al., 2012; Robbins et al., 2017). However, screening tools are much shorter to administer and some can be administered by non-specialists with minimal training, for example NeuroScreen (Robbins et al., 2017). Screening tools with adequate sensitivity and specificity are integral to achieving the goal of assessment of HAND (Robertson et al., 2009; Robertson & Hall, 2007).

In SSA not many screening tools have been validated against the gold standard NP battery to ensure they have good psychometric properties, however two examples of validated screening tools are NeuroScreen, validated in South Africa (Robbins et al., 2017), and the International HIV Dementia Scale (IHDS), validated in South Africa and Uganda (Sacktor et al., 2005). These comprehensive assessments and screening tools are highly influenced by cultural factors such as appropriate language and the availability of norms.

Culture is an important aspect to consider in NP assessment because it influences test results (Fernández & Abe, 2017; Nell, 1999). NP tests developed and used in Western populations need to be culturally adapted for use in SSA. Tests must also be translated into language that can be easily understood by patients (Brickman, Cabo, & Manly, 2006). Using the Hopkins Verbal Learning Test as an example- the use of the category ‘precious stones’ may not be appropriate because the gems may not be known in the region. This category could be replaced with, for example, the category ‘clothing’ (Scott, et al., 2018). In addition, appropriate norms are a necessity for NP testing (Brickman et al., 2006; Robertson et al., 2009).

A small body of test norms for SSA have been collected and published. In Zambia, demographically corrected norms were collected using an English NP test battery covering the seven cognitive domains that should be tested for HAND (Hestad et al., 2016). The AIDS Clinical Trials Group published NP test norms that include three SSA countries (South Africa, Malawi and Zimbabwe) (Robertson et al., 2016). Neuropsychology test norms for the Wechsler Adult Intelligent Scale III (WAIS-III) (Shuttleworth-Edwards et al., 2004) and the Grooved Pegboard for adults with HIV (van Wijk & Meintjes, 2015) are available for South Africa. Thus, appropriate test norms are not available for many SSA countries.

NP assessment is very limited in SSA and faces unique challenges around the types of tests to use as well as personnel to administer the tests, translation and adaptation of tests, and cultural appropriateness of tests. Therefore, the aims of this review are to: i) establish which NP test batteries being used to assess NCI among HIV-infected individuals, ii) describe the adaptations made to the tests, iii) determine normative data that exist for tests being used, and iv) determine the personnel administering these tests.

Method

Search strategy

This systematic review was registered in Prospero (CRD4201705577) and followed PRISMA guidelines. We searched PubMed, Medline, EBSCO, PsycINFO, and Web of Science from inception of the database to January 8th, 2017.

Various combinations of the following search terms were used: “neurocognitive impairment”, “HIV associated neurocognitive disorder”, “HIV associated dementia”, "screening" "assessment", "neuropsychological", "battery", "screening tool", "Sub-Saharan Africa", "Subsaharan Africa", "Africa, South of the Sahara".

Appropriate controlled vocabulary words were included for each database and various combinations of the controlled as well as free text terms were used.

Inclusion criteria

- Patients: HIV positive adults (age 18 or older).
- Assessments: A detailed assessment using a comprehensive test battery with at least 1 test across 6 domains for NCI
- Settings: Only studies conducted in Sub-Saharan Africa.

Exclusion criteria

- We excluded articles that were not peer reviewed, not written in English and abstracts from conferences.

Screening process

- After removing duplicates from the selected articles, two reviewers (PN and DC) independently screened the titles and abstracts according to the inclusion and exclusion criteria. The rate of agreement between the authors was 94%. Where authors disagreed on inclusion or exclusion of an article, differences were discussed and agreement was reached on all discrepancies. Following the screening process, the same two authors retrieved the full texts and reviewed them for inclusion. We included articles with a comprehensive neuropsychological test battery had at least one test per domain in at least six named domains commonly affected by HIV: i) attention, ii) memory, iii) learning, iv) motor functioning, v) processing speed, vi) verbal fluency and vii) executive functioning. Articles that focused on a screening tool only for NCI were excluded because a previously published systematic literature review focused on IHDS use in SSA (Habib et al., 2013) and a recent scoping review focused on screening tools for HAND in SSA (Mwangala, Newton, Abas, & Abubakar, 2018). After completing the screening process, a backward and forward search was conducted to identify any articles that may have been missed from the literature search.

Area Expert Consultation—After the main search was conducted and the final set of eligible articles was generated, we consulted with regional experts in neuropsychology of HIV, as systematic reviews can benefit from discussions with subject area experts (McGowan & Sampson, 2005).

Data extraction—Two independent reviewers (PN and DM) respectively extracted data and checked data for accuracy. Data extracted from the articles were: author, country, main objectives of the study, participant characteristics, description of the neuropsychological tests used to assess NCI personnel who administered the tool, translation/adaptation of the tests, functional assessment, whether a global deficit score (GDS) was used and whether norms were used.

Risk of bias assessment—Risk of bias assessment is important because it provides evidence on the quality of the studies/evidence included in a review (Shamseer et al., 2015). Two reviewers used the NIH Quality Assessment Tool for Cohort and Cross Sectional Studies (National Institutes of Health, 2014) for the risk of bias assessment.

Results

Search Results

We retrieved 212 articles from the five databases. After merging the articles, we removed 91 duplicates. The titles and abstracts of the remaining 121 articles were screened for eligibility and 89 articles were excluded based on the following: the article did not address NCI among HIV-infected individuals, no NCI assessment was included, participants were children, review articles, and the research setting was not in SSA (see Figure 1). We retrieved full texts for the remaining 32 articles and excluded 12 that did not have tests on at least 6 domains and did not have any screening tool/battery. One eligible article was identified from the backward and forward search resulting in a total of 21 suitable articles for this review. An additional final search was conducted on November 30^{th,} 2017 to check if there were any new eligible articles. One paper was added (Robbins et al., 2017). After consulting with area experts, we identified one additional paper (Yakasai et al., 2015) that was not retrieved via database searching.

Quality assessment/risk of bias

All the included studies clearly defined the research questions, research settings where studies were conducted, outcome measures, as well as clearly defined descriptions of the participants. When there were confounding variables, for example viral load and CD4 count, these were controlled for in the majority of the studies. Despite this there are still aspects in these studies that could be sources of bias, for example, none of the studies, bar one provide justification for sample size (Nakasujja et al., 2013) and simply state the number of participants recruited with no further explanation as to how sample size was determined. Only two studies (Hestad et al., 2012; Royal et al., 2016) indicated whether the neuropsychological examiner was blinded to the HIV status of the participants. In another study, the examiner was not blinded to the participants' HIV status, but the examiners were blinded to the time of antiretroviral therapy (ART) initiation (Carlson et al., 2014). Eighteen studies in this review are cross sectional studies that measured neurocognitive outcome at just one time point. Five studies followed up participants and measured neurocognitive outcomes at more than one time point, specifically, 6- and 12-months, (Nakasujja et al., 2013; Sacktor et al., 2014) 3- and 6-months, study entry and then 1 year later (Cross, Combrinck, & Joska, 2013; Joska et al., 2012), and 3-, 6- and 12-months (Carlson et al., 2014).

Characteristics of the included studies

See Table 1 for study characteristics. To summarise, studies were conducted in seven countries: South Africa (n=7), Uganda (n=7), Nigeria (n=4), Zambia (n=2), Malawi (n=1), Cameroon (n=1) and Botswana (n=1). The focus of the studies varied, with the majority of studies assessing neuropsychological functioning as the main objective of the paper. Other studies focused on specific aspects such as neuropsychological performance in relation to cryptococcal disease (Carlson et al., 2014), central nervous system penetration effectiveness of antiretroviral therapy (Cross et al., 2013; Lawler et al., 2011), ApoE allele (Joska, et al., 2010) minocycline treatment (Nakasujja et al., 2013), gender (Royal et al., 2016) and HIV subtype (Sacktor et al., 2014, 2009). Six of the included studies focused on exploring the validity of the neuropsychological tests used for assessment of HAND (Joska et al., 2016; Joska, et al., 2011; Kabuba, Menon, Franklin, Heaton, & Hestad, 2016; Kanmogne et al., 2010; Robbins et al., 2017; Yechoor et al., 2016). All the participants recruited in these studies were aged 18 and older. Most of the studies (n=16) recruited HIV-positive and HIV-negative controls for NCI assessment. Seven of the studies (Joska et al., 2016; Joska, Fincham, Stein, Paul, & Seedat, 2010a; Kabuba, et al., 2016; Kanmogne et al., 2010; Robbins et al., 2017; Sacktor et al., 2014, 2009; Yechoor et al., 2016) recruited HIV-positive participants only. The sample sizes for these studies range from 60 to 266. Functional assessments were conducted in the majority (16 out of 23) of the studies and GDS was used in 10 out of 23 of the studies (See Table 1).

Comprehensive neuropsychological tests characteristics

Table 2 lists the NP test battery used by each study. Table 3 lists tests commonly used in the different cognitive domains, specifically information processing speed, verbal learning and memory, attention/working memory, executive functioning, motor functioning and verbal fluency. The most commonly used test for each domain is: *Executive function* – Color Trails II; *Learning and memory* – HVLT-R; *Speed of Information processing* - Color Trails I; *Attention/Working Memory* - Digit Span Forward and Backward; *Motor Function* - Grooved Pegboard; and *Verbal Fluency* - Category Fluency (Nouns).

The Grooved Pegboard, a test of motor function, is the most commonly used test and was included in all 23 studies that used a comprehensive test battery. In the domains of executive function, learning, memory, speed of information processing and motor functioning at least two tests were used more commonly than others to test those domains (see Table 3). However, in the attention/working memory and verbal fluency domains a wide range of tests were used across the studies with no one test being preferred by researchers.

Screening tools

Some studies administered screening tools alongside the comprehensive NP test batteries. See Table 4 for a list of screening tools across studies. These screening tools were used in studies from countries-South Africa, Malawi, Nigeria and Uganda (see Table 4). The following screening tools were used:

The International HIV Dementia Scale (IHDS): The IHDS can be administered in about 3 minutes by non-specialists and it consists of finger tapping, hand sequence test and recall (Sacktor et al., 2005). It has a sensitivity of 80% and a specificity of 55% (Sacktor et al., 2005). It was used in South Africa (Joska et al., 2016), Uganda (Sacktor et al., 2009) Nigeria (Royal et al., 2016), and Malawi (Kelly et al., 2014).

The Montreal Cognitive Assessment (MoCA): The MoCA takes approximately 10 minutes to administer and it tests short-term memory recall, visuospatial abilities, executive function, attention, concentration, working memory, language and orientation to time and place (Nasreddine et al., 2005). The MoCA was designed to identify mild cognitive impairment and has a sensitivity of 90% and a specificity of 87% (Nasreddine et al., 2005). It was used in South Africa (Joska et al., 2016)

Mini Mental State Exam (MMSE): The MMSE assesses cognitive mental status and takes 5–10 minutes to administer. Questions assess orientation, registration, attention and calculation, recall, and language (Folstein, Folstein, & McHugh, 1975). It was used in South Africa (Joska et al., 2016)

Cognitive Assessment Tool-Rapid Version (CAT-rapid): The CAT-rapid can be administered by pen and paper or on a smartphone. It has sensitivity of 78% and specificity of 54% (Joska et al., 2016). It measures subjective report of functional symptoms and executive functions.

CogState Brief Battery: This brief battery is used to assess cognitive change over time using tasks on reaction time, working memory and recognition visual learning (Maruff et al., 2009). It takes approximately 25 minutes to administer on a computer and was used in Uganda (Yechoor et al., 2016). The sensitivity and specificity of the battery in a HIV population is 81% and 70% respectively.

NeuroScreen: NeuroScreen consists of ten NP tests that briefly assess individuals across seven NP domains most affected by HIV: verbal learning, memory, processing speed, two visual discrimination tasks, attention/concentration, executive functioning and motor functioning. It is a mobile health (mhealth) tablet-based screener that was developed to be administered by lay health workers and it takes approximately 25 minutes to administer. Sensitivity and specificity ranges from 81% – 93% and 71% – 81% respectively (Robbins et al., 2017).

Neuropsychological tests translations and adaptation

Neuropsychological tests were translated into six languages: French in Cameroon (Kanmogne et al., 2010), Luganda in Uganda (Robertson et al., 2007a; Sacktor et al., 2014, 2009; Wong et al., 2007; Yechoor et al., 2016), isiXhosa in South Africa (Joska, et al., 2011a; Robbins et al., 2013, 2017), Setswana in Botswana (Lawler et al., 2011), Chichewa in Malawi (Kelly et al., 2014), and Afrikaans in South Africa (Joska et al., 2010; Joska, et al., 2011a). Only one study describes the translation process that was used to translate the tests (the standard forward-and back-translation technique) Robbins et al., 2017). In South Africa, translations were reviewed by the isiXhosa speaking research staff to ensure that the language used matched language used by participants and that outdated or overly formal language was not used (Robbins et al., 2017). Six studies conducted tests in English only - four studies in Nigeria (Akolo et al., 2014; Royal et al., 2016, 2012; Yakasai et al., 2015) and two studies in Zambia (Hestad et al., 2012; Kabuba et al., 2016).

The word lists used in the domains of verbal learning and memory were adapted to meet cultural norms in some instances. In Nigeria the word lists were replaced with more locally familiar words after a pilot study was conducted (Akolo et al., 2014; Royal et al., 2016). The Malawian study (Kelly et al., 2014) used a Chichewa word list from a prior neurocognitive functioning study (Robertson et al., 2011). In South Africa the word list was adapted to reflect local culture but the details are not provided (Joska, et al., 2011a). In Cameroon the HVLT-R used was translated and validated in a previous study (Kanmogne et al., 2010) and in Uganda (Yechoor et al., 2016) tests and translated instructions used in a previous study (Robertson et al., 2007a) were used. In Zambia(Kabuba et al., 2016), the HVLT-R adapted in a previous norming study by replacing names of the precious stones with common metals found in Zambia (Hestad et al., 2016) was used.

Norms

Many of the studies do not have relevant norms to compare data to and matched controls are used in some instances where norms are not available. Eighteen studies recruited HIV-negative controls. Five studies used norms available in Uganda and Zambia and therefore only recruited HIV-positive participants (Kabuba et al., 2016; Nakasujja et al., 2013; Sacktor et al., 2014, 2009; Yechoor et al., 2016). Two studies in South Africa recruited HIV-positive participants only, but did not specify which norms were used (Joska et al., 2016; Robbins et al., 2017).

Personnel administering tests

Personnel who administered the neuropsychological tests were specified in ten studies (see Table 1). Only one study used a neuropsychologist for test administration, and they also used a medical student to administer tests (Lawler et al., 2011). In Zambia, 10 Neuropsychology Master's degree students administered the tests (Kabuba et al., 2016). Other study personnel who administered neuropsychological testing were nurses, clinicians, clinical psychologists, neuropsychology technicians/trained administrators, 'research staff", and lay counsellors and neuropsychology examiners.

Discussion

This systematic review explored the assessment of NCI among HIV-infected individuals to determine which NP tests are being used to assess NCI among HIV-infected individuals and to describe test adaptations, norms, and personnel administering the neuropsychological tests. The articles in this review reflect research done in a handful of countries across SSA, the region in the world that is most affected by the HIV epidemic (World Health Organization, 2016).

The review delivered six key findings: i) studies on NCI among HIV-infected individuals published in English that met our eligibility criteria were done in 7 out of 46 countries in SSA; ii) studies have variable sample sizes ranging from 60 – 266; iii) similar NP batteries were used to assess NCI among HIV-infected individuals across the countries captured in this review; iv) across countries tests were adapted and translated to suit local needs; v) three of the seven countries have local norms (note that these norms may not be appropriate for all populations); and vi) NP batteries and screening tools are mostly administered by non-specialists.

The highest number of studies were conducted in South Africa, (N=7) which has an HIV prevalence rate of 19% (UNAIDS, 2016) and Uganda (N=7), which has an HIV prevalence rate of 6.5% (UNAIDS, 2016a). Regarding sample size, while HIV is highly prevalent in SSA, the sample sizes of the studies are generally small with the exception of a study where 266 HIV positive adults were recruited in Zambia (Kabuba et al., 2016). Most of the studies (N=23) did not report power analyses and/or justifications for the small sample sizes or comment on how the actual sample size could affect the interpretation of differences in performance on tests between HIV-positive and HIV-negative groups. Due to this, findings from these studies should be interpreted with caution as small sample sizes may result in exaggerated findings and therefore unreliable results (Button et al., 2013). Despite these shortcomings, the studies provide valuable descriptions of neuropsychological tests and screening tools used for assessing HIV associated neurocognitive impairment in the SSA setting.

A total of six different screening tools were used alongside comprehensive assessments in the studies in this review. Screening tools that are easy to use and have good psychometric properties are needed for low resource settings such as SSA. The NeuroScreen and the CogState brief battery may meet these criteria as evidenced by their high sensitivity and specificity (Robbins et al., 2017; Yechoor et al., 2016). These screening tools take approximately 25 minutes to administer and are tablet based as opposed to the traditional pen-and-paper based tests. The use of technology/mHealth in neurocognitive assessment is in keeping with modern healthcare and there is need to detail the benefits and potential pitfalls of using this technology (Parsons, McMahan, & Kane, 2018). It is also important for mHealth screening tools to remain up to date with technological advances so that its utility remains relevant (Parsey & Schmitter-Edgecombe, 2013). The option to have either a pen-and-paper based administration or using a mHealth based administration, as is the case with the Cat-Rapid (Joska et al., 2016), will accommodate people who may not be able to use mHealth devices. Using screening tools that detect HIV-associated neurocognitive impairment is important. The MMSE, used in one study in this review (Joska et al., 2016), has been criticised for being insensitive to identifying HIV-related impairment (Valcour, Paul, Chiao, Wendelken, & Miller, 2011). On the other hand, the MoCA has been used in HIV-positive populations and both have very short administration times and good sensitivity and specificity.

Regarding comprehensive assessment across countries, studies shared at least two common tests per domain with the exception of attention/working memory and verbal fluency domains. All these shared tests have been recommended by the HIV Neurobehavioural Research Center (HNRC) (Robertson et al., 2009). This is promising for cross-country sharing of expertise and for developing standardised neurocognitive assessments in SSA. Standardised tests will provide accurate neurocognitive assessments that can be compared across different settings. While recognising that a comprehensive neuropsychological test battery is the gold standard for diagnosing NCI among HIV-infected individuals, there are challenges. The cost of tests are prohibitive and most countries in SAA lack trained professionals to administer and interpret test batteries (Moore et al., 2012). Furthermore, the requirement for continued purchase of expensive record sheets is unrealistic in this setting. Administering a comprehensive battery is also time consuming (Joska et al., 2016; Kabuba et al., 2016; Moore et al., 2012). This means that few patients can be seen at any one time. Some studies in this review used a global battery approach to define impairment. This could be impractical if interventions only target specific domains. It might be better to move towards a domain approach as various newer cognitive interventions target specific domains (Vance et al., 2018).

The tests used in these studies were developed primarily in the United States and for English speakers and do not implicitly address the challenges that SSA faces with its many languages and varied cultures. This review shows that tests were translated into six African languages: Afrikaans, Chichewa, French, isiXhosa, Luganda, and Setswana. Using these tests in the language that the participant is, at least, conversational in ensures that test items are understood by the participant and that we are assessing what the test intends to measure, thus improving accurate data collection on cognitive functioning (Brickman et al., 2006). Two shortcomings in the reviewed studies are that many authors do not discuss the translation process of either tests or test instructions, neither do they indicate who the personnel were who conducted the assessments. Future studies should report on translation methods.

NP tests require cultural adaptation (Nell, 1999; Robertson & Hall, 2007) in addition to translation to meet cultural norms. While the Hopkins Verbal Learning Test (Brandt & Benedict, 2001) was adapted for use in Nigeria (Akolo et al., 2014; Royal et al., 2016), Malawi (Kelly et al., 2014) Zambia (Kabuba et al., 2016a) and South Africa (Joska, et al., 2011a) none of the authors explicitly mention how the adaptations were made. This information would be of value to fellow researchers who may need to adapt the test for other languages and who would like to ascertain the suitability of the adaptations to their populations.

A key element in NP testing is having normative data to compare patient performance to. NP test norms have been published for 4 SSA countries - Zambia (Hestad et al., 2016), Malawi, Zimbabwe (Robertson et al., 2016) and South Africa (Robertson et al., 2016; Shuttleworth-Edwards et al., 2004; van Wijk & Meintjes, 2015). While these norms are relevant to the specific populations in these countries where the norms were collected, it is not currently known whether they can be generalised to other populations within the same country, or similar populations elsewhere in SSA. These norms should therefore be used with caution in populations other than that specified by the researchers until further studies have been done to confirm that these norms are generalisable to other populations. For the time being, researchers should include appropriate comparison groups when conducting research and continue to do so even as norms become available.

Regarding reporting on staff who administered NP tests and screening tools, most of the studies did not use a neuropsychologist or clinical psychologist to administer the full battery. The studies that mention the personnel who administered the tests do not mention the qualifications or experience of the personnel nor the training they were given. Studies do however specify that personnel are supervised by either clinical or neuropsychologists. Specialised personnel, with the required neurological and neuropsychological skills are scarce in low resource settings (Robertson et al., 2009). Knowing which staff was used to administer the tests in the different studies can inform research and clinical practice. This review implies that task shifting of neuropsychological testing with appropriate supervision and training is possible in SSA settings. Lay health workers in clinics can also be trained to use screening tools such as the NeuroScreen (Robbins et al., 2017). Through this task shifting approach, screening and comprehensive assessment of NCI among HIV-infected individuals can be implemented in clinics in low-resource settings. This may also apply to neurocognitive assessment in general and just in HIV populations.

Limitations

Studies that met this review's inclusion criteria were conducted in only seven of 46 countries in the SSA region illustrating that research assessing NCI among HIV-infected individuals in the region is limited. Only studies published in English were included in this review. It is further not clear that data from these studies can be generalised to other population groups or countries. The stringent inclusion criteria requiring assessment of at least six domains consisting of executive functioning, verbal fluency, information processing speed, learning, memory, motor functioning and attention/working memory resulted in the exclusion of studies that excluded one or more of these domains. We however considered these inclusion criteria necessary in order to have articles that administered a comprehensive assessment. We did not include studies that used only the IHDS because of the recent systematic review that was published on it (Habib et al., 2013) and also studies that focused on a screening tool only because of the recent scoping review by Mwangala et al. (2018).

According to the Risk of Bias Assessment (National Institutes of Health, 2014) the studies in this review are of moderate quality, are largely cross sectional and have small sample sizes. Some of the studies lacked comprehensive explanations on the personnel who administered the tests, the frequency of the training given and how tests were adapted/translated. This limited the conclusions that we could draw regarding training required by staff and whether tests used were culturally appropriate. This is particularly important in the context of task-shifting, which is common in SSA, and previous research has described potential problems with lay health workers administering neurocognitive screening tools (Breuer et al., 2012; Robbins, Remien, Mellins, Joska, & Stein, 2011). This limited the conclusions that we could draw regarding training required by staff and whether tests used were culturally appropriate. Our review did not include studies on children or adolescents.

Conclusions

This review is the first step to getting a better understanding of neurocognitive assessment of PLWH who also have NCI. Few countries in SSA are conducting NCI research and this could be due to the massive lack of skills or awareness of NCI among HIV-infected individuals in SSA. Tests used in the comprehensive NP assessments are similar to the gold standard tests used globally to assess NCI among HIV-infected individuals. Despite being developed in the West, NP tests can be adapted for use in SSA settings. There is a global movement towards a task shifting approach especially in SSA. Lay health workers can be trained to assess NCI among HIV-infected individuals using some of the assessment tools, as illustrated in the study from South Africa using NeuroScreen (Robbins et al., 2017).

NP tests should be validated in these SSA settings to ensure cultural appropriateness of tests. Culturally valid neuropsychological tools will contribute to the implementation of neurocognitive assessment in SSA and enable screening and diagnoses of neurocognitive disorders. Norms must be collected so that test results can be interpreted correctly. Acquiring appropriate norms for SSA populations is an area that urgently requires further research. There is further a need to translate research findings to clinical practice so that it can be incorporated into routine care for HIV-positive patients in clinic settings. Future research should focus on how this can be done and ascertain the training needed and other factors required to make this possible.

From the studies in this review, at least in a research context, NCI among HIV-infected individuals can be assessed in SSA countries. There is a need for implementation studies in this region so that patients can start to benefit from this knowledge in primary health care settings.

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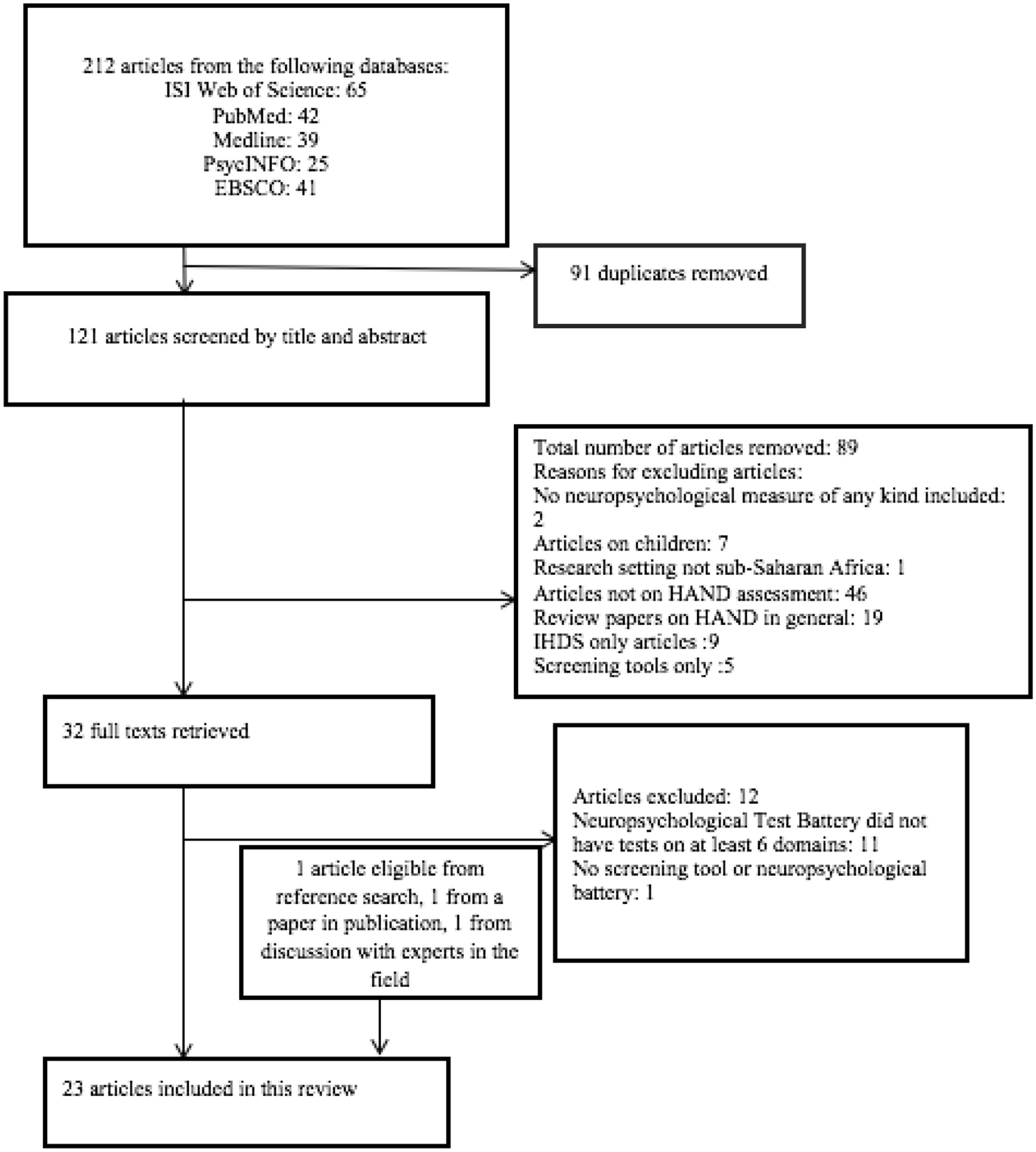

Figure 1.
Literature Search Results

Table 1.

Characteristics of the Included Studies

Author (Year)	Country of study	Summary of main objectives	Participants recruited	Functional Assessment Done	Personnel administering tests	Norms/Control Group Recruited	Global Deficit Score	Translation/ Adaptation of tests
Akolo et al. (2014)	Nigeria	Reporting results of an analysis of neuropsychological data on HIV positive adults	133 Seropositive and 77 Seronegative participants Aged 18 and above	No	2 nurses trained by a neuropsychological testing technician	Yes-control group recruited	Yes	Only English speakers were recruited and unfamiliar terms in the verbal tests were replaced with more familiar terms
Carlson et al. (2014)	Uganda	Assessment of neurocognitive function in people who have had AIDS-related cryptococcal meningitis over 12 months	78 HIV positive and cryptococcal meningitis 110 HIV positive controls without meningitis 11 HIV negative controls aged 18 and above	Yes-ADL and Karnofsky	Not Mentioned	Yes- control group recruited	Yes	Not Mentioned
Cross et al. (2013)	South Africa	Examining the effect of ART Cerebrospinal Fluid Penetration Effectiveness on cognitive function in people living with HIV	103 HIV negative controls 111 HIV positive participants (69 eligible for CPE analysis: 31 were in the low CPE category and 38 in the high CPE category) aged between 18 and 35	No	Not Mentioned	Yes-control group recruited	Yes	Not Mentioned
Hestad et al., (2012)	Zambia	Examining Neuropsychological functioning of HIV positive and negative adults	38 HIV positive and 42 HIV negative participants aged between 20–40 years	Yes-PAOFI and IADL	Neuropsychological examiner masked on HIV status of participants	Yes-control group recruited	No	English
Joska et al. (2010)	South Africa	Establishing the distribution of the ApoE allele in South Africa	144 HIV positive and 50 HIV negative controls aged between 18 and 40.	Yes-self report	Not mentioned	Yes-control group recruited	No	Forward and back translations of all instruments into isiXhosa and Afrikaans

Author (Year)	Country of study	Summary of main objectives	Participants recruited	Functional Assessment Done	Personnel administering tests	Norms/Control Group Recruited	Global Deficit Score	Translation/ Adaptation of tests
Joska, et al., (2011)	South Africa	Describing the performance of the IHDS compared to the HAND categories	96 HIV positive and 94 HIV negative adults aged between 18 and 40.	Yes-PAOFI and QLESQ	Trained Technicians	Yes-control group recruited	No	World lists were changed to suit local language and idioms Forward and back translation of instruments in isiXhosa
Joska et al. (2011a)	South Africa	Evaluation of Neurocognitive Disorders and Risk Factors among HIV positive participants not yet on HAART	170 HIV positive ART naïve adults and 51 HIV negative adults aged between 18 and 35 years	Yes-PAOFI and QLESQ	Not mentioned	Yes-control group recruited	No	World lists were changed to suit local language and idioms Forward and back translation of instruments in isiXhosa and Afrikaans
Joska et al. (2012)	South Africa	Assessing neuropsychological functioning over 1 year of people initiating HAART over	166 HIV positive and 120 HIV negative participants	No	Not Mentioned	Yes-control group recruited	Yes	Not Mentioned
Joska et al. (2016)	South Africa	Comparing screening tools for HAND and assessing the validity of the CAT-rapid	156 HIV positive adults	Yes-LADL	Not Mentioned	No-control group recruited. Norms used but not specified	Yes	Not Mentioned
Kabuba et al. (2016)	Zambia	To determine the sensitivity of the HIV Neurobehavioral Research Centre (HNRC) battery using Zambian norms, to determine the neuropsychological impairment levels and examine how HIV disease characteristics affect neuropsychological test performance	266 HIV positive adults aged between 18 and 65 years	Yes-PAOFI and ADL	Master of Science students in Neuropsychology who had been trained extensively on the test battery	No control group recruited and demographically corrected neuropsychological test norms from Zambia were used	Yes	Tests were conducted in English. During the norming process- some items in the Hopkins Verbal Learning Test Revised were replaced with more culturally appropriate terms
Kanmogne et al. (2010)	Cameroon	Adaptation of the HIV Neurobehavioral Research Centre Battery and explore its validity in Cameroon	44 HIV positive and 44 HIV negative adults aged between 18 and 60 years old	No	Psychologists trained in psychometrics	Yes-control group recruited	No	Test Instructions and Test Battery was translated to French.
Kelly et al. (2014)	Malawi	To provide normative values	113 HIV positive and	Yes-Karnofsky	Study clinician who was trained on test	Yes-control group recruited	Yes	The Chichewa

Author (Year)	Country of study	Summary of main objectives	Participants recruited	Functional Assessment Done	Personnel administering tests	Norms/Control Group Recruited	Global Deficit Score	Translation/ Adaptation of tests
		for a neurocognitive test battery and estimate prevalence of HAND in Malawians on cART	103 HIV negative aged 18 and above	Performance Score	administration prior to the study starting			version of the HVLT-R was used. The tests were translated into Chichewa
Lawler et al. (2011)	Botswana	To assess HAND prevalence and effectiveness of HAART with differing CPE scores	60 HIV positive adults and 80 HIV negative adults aged 18 to 50	Yes- ADL	A Neuropsychologist and a Motswana medical student fluent in both Tswana and English trained and supervised by a Neuropsychologist.	Yes-control group recruited	No	Forward and Back translation into Setswana
Nakasujja et al. (2013)	Uganda	Efficacy of minocycline in treating HIV associated neurocognitive impairment in Uganda	73 HIV positive adults	Yes- Karnofsky Scale and IADL.	Research Assistants	No control group recruited, used norms from a study in Uganda (Robertson, 2007a)	No	Not Mentioned
Robbins et al. (2017)	South Africa	Validation of a tablet based screener, NeuroScreen in HIV patients	102 HIV positive adults age 18 and above	No	Trained Research Staff supervised by a neuropsychologist (full battery) Lay counsellors (screener)	No control group recruited, norms used not specified	Yes	Instructions and content translated to isiXhosa. Tests were administered in English or isiXhosa. A culturally adjusted verbal list learning test was used.
Robertson et al. (2007a)	Uganda	Neuropsychological performance of HIV positive patients compared to HIV negative adults	110 HIV positive and 100 HIV negative adults aged 18 and above	Yes- functional status survey	Test Administrators Fluent in both English and Luganda	Yes-control group recruited	No	Instructions and content translated to Luganda.
Royal et al. (2012)	Nigeria	To assess cognitive impairment in HIV positive adults using a screening tool and a neuropsychological battery	60 HIV positive and 56 HIV negative participants aged 18 and above. Of these 11 HIV positive and 15 HIV negative participants received the detailed assessment.	Yes- Karnofsky Scale	Not Mentioned	Yes-control group recruited	No	Tests were administered in English.
Royal et al. (2016)	Nigeria	Description of gender differences in Neuropsychological battery performance	58 HIV negative and 149 HIV positive participants aged 18 and above	No	An examiner who was blinded on the HIV status of the participants	Yes-control group recruited	Yes	Tests were administered in English. Words on the verbal tests, which were not familiar,

Author (Year)	Country of study	Summary of main objectives	Participants recruited	Functional Assessment Done	Personnel administering tests	Norms/Control Group Recruited	Global Deficit Score	Translation/ Adaptation of tests
								were replaced with more familiar terms.
Sacktor et al. (2009)	Uganda	To determine the HIV subtype in adults commencing ART and evaluating the relationship between the HIV subtype and their neurocognitive impairment	60 ART naïve adults aged 18 and above	Yes-Karnofsky Performance Status Scale	Not mentioned	No control group recruited, used norms from a study in Uganda (Robertson, 2007a)	No	Tests were translated into Luganda
Sacktor et al. (2014)	Uganda	To determine the frequency of HIV dementia and its association with HIV subtype	117 ART naïve adults aged 18 and above	Yes-Karnofsky Scale and IADL	Not Mentioned	No control group recruited, used norms from a study in Uganda (Robertson, 2007a)	No	Evaluations were conducted in Luganda
Wong et al. (2007)	Uganda	To determine the frequency of HIV dementia and its associated factors	78 HIV positive and 100 HIV negative participants aged 18 and above	Yes-Karnofsky Scale	Not Mentioned	Yes-control group recruited	No	The content and instructions of all tests administered were translated to Luganda
Yakasai et al. (2015)	Nigeria	To determine prevalence rates of HAND in Nigeria	80 HIV positive and 40 HIV negative participants aged 18 and above	Yes-PAOFI, IADL and Karnofsky performance scale	Not mentioned	Yes-control group recruited	No	Only people fluent in English were recruited
Yechoor et al. (2016)	Uganda	Comparison of performance on the Cog State brief battery to the gold standard neuropsychological test battery	181 HIV positive adults aged between 18 and 50.	No	A trained research assistant	No control group recruited, used norms from a study in Uganda (Robertson, 2007a)	Yes	Option to take the battery in either English or Luganda. The CogState battery instructions were in English

Abbreviations: ART: Antiretroviral Therapy; HAART: Highly Active Antiretroviral Therapy; ADL: *Activities of Daily Living*; IADL: *Instrumental Activities of Daily Living*; PAOFI: *Person's Assessment of Own Functioning*; QLESQ: *Quality of Life Enjoyment and Satisfaction Questionnaire*; LADL: *Lawton Activities of Daily Living*.

Table 2.

Tests Used in the Comprehensive Neuropsychological Battery

Author (Year)	Screening Tool Used	Domains and Tests in Comprehensive battery
Akolo et al. (2014)	None	**Speed of Information Processing:** WAIS-III Digit Symbol, WAIS III Symbol Search, Color Trails Test 1, Trail Making Test A **Attention/Working Memory:** PASAT, WMS-III Spatial Span **Executive Functioning:** Color Trails 2, Stroop Color and Word Test **Learning:** HVLT-R learning, BVMT-R learning **Memory:** HVLT-R delayed recall, BVMT-R delayed recall **Verbal Fluency:** Letter (Word Sound) Fluency, Category Fluency Nouns (animals), Category Fluency Verbs (Actions) **Motor Speed and Dexterity:** Grooved Pegboard, Finger Tapping Test, Timed Gait
Carlson et al. (2014)	None	**Speed of Information Processing, Concentration:** WAIS-III Symbol Digit **Speed of Information Processing, Attention:** Color Trails 1 **Attention/Working Memory:** Digit Span Forward and Backward **Executive Function:** Color Trails 2 **Verbal Learning:** WHO-UCLA Auditory Verbal Learning Test-Total **Verbal Memory:** WHO-UCLA Auditory Verbal Learning Test-Delayed Recall **Language Fluency (Verbal)** Semantic Verbal Fluency (Animals) **Gross Motor:** Timed Gait **Fine Motor:** Grooved Pegboard **Motor Speed:** Finger Tapping Test
Cross et al. (2013)	None	**Processing Speed:** Digit Symbol Coding, Color Trails 1, Trail Making Test A **Attention:** Mental Alternation Test, Wechsler Memory Scale III mental control scores **Executive Function:** Color Trails II, Stroop Color Word, Wisconsin Card Sorting Test perseverative errors and Rey-Osterrieth Complex Figure copy scores **Learning:** HVLT recall BVMT recall **Verbal:** Animal and fruit/vegetable fluency scores **Motor:** Grooved Pegboard, Finger Tapping Test
Hestad et al. (2012)	**None**	**Speed of Information Processing:** Stroop-Color Word, WAIS III Digit Symbol, WAIS III Symbol Search, Color Trails I, TMT-A **Working Memory:** PASAT-50, WMS-III Spatial Span **Executive Functions:** Category Test, Color Trails 2, WCST-64 **Verbal Episodic memory:** HVLT-R learning and delayed recall **Visual Episodic Memory:** BVMT-R learning and delayed recall **Verbal Fluency** Letter Fluency, Animal Fluency, Action Fluency **Motor Function:** Grooved Pegboard,
Joska et al. (2010)	**None**	**Psychomotor Speed:** Trail Making Test Part A, Color Trails Test 1, Digit Symbol Coding **Attention:** Mental Alternation Test, Mental Control Test **Executive Function:** Color Trails Test 2, Stroop Color Word Test, WCST, Rey Complex Figure **Learning and Memory:** HVLT and BVMT **Motor:** Finger tapping and Grooved Pegboard **Language:** Category Fluency Animals and Category Fluency Fruit and Vegetables
Joska et al. (2011)	**IHDS**	**Psychomotor Speed:** Trail Making Test Part A, Color Trails Test 1, Digit Symbol Coding **Attention:** Mental Alternation Test, Mental Control Test **Executive Function:** Color Trails Test 2, Stroop Color Word Test, WCST **Learning and Memory:** HVLT and BVMT **Motor:** Finger tapping and Grooved Pegboard **Category Fluency:** Animal list, Fruit and Vegetable list
Joska et al. (2011a)	**None**	**Psychomotor Speed:** Digit Symbol Coding, Color Trails I, TMT-A **Attention:** Mental Alternation Test, Mental Control Test **Executive Function:** Color Trails 2, Stroop Color Word Test, WCST, Rey Complex Figure **Learning and Memory:** HVLT and BVMT **Language:** Category Fluency animals and Category Fluency Fruits and Vegetables **Motor:** Grooved Pegboard, Finger Tapping
Joska et al. (2012)	**None**	**Psychomotor Speed:** Digit Symbol Coding, Color Trails I, TMT-A, Grooved Pegboard, Finger Tapping **Attention:** Mental Alternation Test, Mental Control Test **Executive Function:** Color Trails 2, Stroop Color Word Test, WCST **Learning and Memory:** HVLT and BVMT **Language:** Category Fluency

Author (Year)	Screening Tool Used	Domains and Tests in Comprehensive battery
Joska et al. (2016)	**IHDS** **MOCA** **MMSE** **SSQ** **CAT-rapid**	**Psychomotor Speed:** Grooved Pegboard **Attention/Concentration:** Mental Alternation Test, WAIS Digit Symbol Coding, Digit Span **Executive Function:** Color Trails test, Stroop Color Word Test, WCST **Learning/Memory:** HVLT and Rey Complex Figure Test
Kabuba et al. (2017)	**None**	**Speed of Information Processing:** WAIS-III Digit Symbol, WAIS III Symbol Search, Color Trails Test, 1, Trail Making Test A, Stroop color and word naming **Attention/Working Memory:** PASAT, WMS-III Spatial Span **Executive Functions:** Color Trails 2, Stroop –color Word, WCST-64 **Learning:** HVLT-R learning, BVMT-R learning **Delayed Recall:** HVLT-R delay BVMT delay **Verbal Fluency** Letter Fluency, Animal Fluency, Action Fluency **Motor Function:** Grooved Pegboard
Kelly et al. (2014)	**IHDS used to screen for HAND**	**Attention and Speed of Information Processing:** WAIS Digit Symbol, Color Trails 1 **Set Shifting and Response Inhibition:** Color Trails 2 **Learning and Memory:** HVLT-R **Language Fluency** Semantic Verbal Fluency **Gross Motor Skills:** Timed Gait **Fine Motor Skills:** Grooved Pegboard, Finger Tapping Test
Kanmogne et al. (2010)	None	**Speed of Information Processing:** WAIS-III Digit Symbol, WAIS III Symbol Search, Stroop Color, Color Trails 1 Trail Making Test A **Attention/Working Memory:** PASAT, WMS-III Spatial Span **Executive Functions:** Category Test, WCST-64, Color Trails II **Learning:** HVLT-R learning, BVMT-R learning **Memory:** HVLT-R delay recall, BVMT-R delay recall **Verbal Fluency** Letter Fluency, Animal Fluency, Action Fluency **Motor Function:** Grooved Pegboard
Lawler et al. (2011)	None	**Processing:** Symbol Digit Coding **Psychomotor Speed:** Trail Making Test A **Executive Functions:** Color Trails 2 **Verbal Learning and Memory:** Botswana Auditory Verbal Learning Test **Language:** Action Fluency **Fine Motor Speed/Dexterity:** Grooved Pegboard
[1]Nakasujja et al. (2013)	None	Timed Gait, Grooved Pegboard, Color Trails I, Colour Trails 2, Symbol Digit, WHO-UCLA Verbal Learning Test and delayed recall, digit span forward and backward,
Robbins et al. (2017)	NeuroScreen	**Processing Speed:** WAIS-III Digit Symbol Coding, Color Trails Test I, TMT-A, Symbol Search **Attention/Concentration:** Wechsler Memory Scales, Third Edition [WMS-III] Spatial Span and Wechsler Adult Intelligence Scales, Third Edition [WAIS-III] Digit Span **Executive Functioning:** Color Trails 2, WCST. **Learning and Memory:** HVLT-R and BVMT-R, **Language:** Semantic Fluency (animals, and fruit and vegetables) **Motor Functioning:** Grooved Pegboard, Successive Finger Tapping
Robertson et al. (2007a)	None	**Speed of Processing:** Color Trails 1, Symbol Digit Modalities **Attention/Working Memory:** Digit Span Forward and Backward **Executive Functioning:** Color Trails 2 **Verbal Learning/Memory:** WHO-UCLA Auditory Verbal Learning Test **Gross Motor:** Timed Gait **Fine Motor**: Grooved Pegboard
Royal et al. (2012)	IHDS	**Speed of Information Processing:** WAIS-III Digit Symbol, WAIS III Symbol Search, Color Trails Test 1 Trail Making Test A **Attention/Working Memory:** PASAT, WMS-III Spatial Span **Abstraction/Executive Functioning:** WCST-Computer Version, Color Trails 2, Stroop Color and Word Test, Halstead Category Test **Learning and Delayed Recall:** HVLT and BVMT **Verbal Fluency:** Letter (Word Sound) Fluency, Category Fluency **Motor Speed and Dexterity:** Grooved Pegboard **Screening for Effort:** Hisock Digit Memory Test
Royal et al. (2016)	None	**Speed of Information Processing:** WAIS-III Digit Symbol, WAIS III Symbol Search, Color Trails Test 1 Trail Making Test A **Attention/Working Memory:** PASAT, WMS-III Spatial Span **Executive Functions:** Color Trails Test 2, Stroop Color and Word Test **Learning:** HVLT-R, BVMT-R **Memory:** HVLT-R delayed recall, BVMT-R delayed recall

Author (Year)	Screening Tool Used	Domains and Tests in Comprehensive battery
		Verbal Fluency Letter (Word Sound) Fluency, Category Fluency Nouns (animals), Category Fluency Verbs **Motor Speed and Dexterity:** Grooved Pegboard, Finger Tapping Test, Timed Gait **Screening for Effort:** Hisock Digit Memory Test
Sacktor et al. (2009)	IHDS	**Psychomotor Speed:** Color Trails Test, Symbol Digit **Attention:** Digit Span Forward and Backward **Verbal Memory/Learning:** WHO-UCLA Auditory Verbal Learning Test **Verbal Fluency:** Category Naming Test **Motor Performance:** Finger tapping test, timed gait, grooved pegboard
Sacktor et al. (2014)	None	**Psychomotor Speed:** Grooved Pegboard **Attention:** Digit Span Forward and Backward **Verbal Memory/Learning:** WHO UCLA Verbal Learning Test **Executive Function:** Color Trails test, Symbol Digit modalities test **Motor Performance:** Finger tapping test **Verbal Fluency:** Category Naming Test
Wong et al. (2007)	None	**Speed of Processing and Executive Function:** Color Trails 1 and 2, symbol digit modalities **Attention and Working Memory:** Digit Span Forward and Backward **Verbal Learning and Memory:** WHO-UCLA Auditory Verbal Learning Test **Motor Functioning:** Grooved Pegboard, Timed Gait
Yakasai et al. (2015)	None	**Speed of Information Processing:** Wechsler Adult Intelligence Scale III (WAIS-III) Symbol Search **Attention/Working Memory:** Wechsler Memory Scale (III) Spatial Span **Learning:** HVLT-R Immediate Recall **Memory:** Hopkins Verbal Learning Test-Revised (HVLT-R) Delayed Recall and Trial Recognition **Abstraction/Executive Function:** Color Trails 2 **Verbal Letter Fluency:** Controlled Oral Word Association Test (COWAT-FAS) **Motor:** Grooved Pegboard Dominant Hand (DH) And Nondominant Hand (NDH)
Yechoor et al. (2016)	CogState Brief Battery	**Speed of Information Processing:** Color Trails 1 **Attention:** Digit Span Forwards and Backwards **Executive Functioning:** Color Trails 2 **Verbal Learning and Verbal Memory:** WHO-UCLA Auditory Verbal Learning Test **Sensory-Perceptual Motor Skills:** Grooved Pegboard

Abbreviations: BVMT-R: *Brief Visuospatial Memory Test Revised*, HVLT-R: *Hopkins Verbal Learning Test Revised*, PASAT: *Paced Auditory Serial Addition Test*, TMT-A: Trail Making Test A; WAIS: *Wechsler Adult Intelligence Scale*, WMS: *Wechsler Memory Scale*, WCST: *Wisconsin Card Sorting Test*, WHO-UCLA: *World Health Organisation-University of California Los Angeles*

Note: The domains listed above are listed as they are written in the articles. Tests listed as written by authors. 1The author did not list the domains.

[1]The author did not list the domains.

Table 3.

Commonly Used Tests in the Comprehensive Test Batteries in Sub-Saharan Africa

Domain	**Tests Used**	**Number of Studies out of 23**
Speed of Information Processing	Color Trails Test 1	19
	WAIS-III Digit Symbol	18
	Trail Making Test A	13
	WAIS-III Symbol Search	8
	Symbol Digit Modalities	1
Attention/Working Memory	Digit Span Forward and Backward	10
	WMS-III Spatial Span	8
	PASAT	7
	Mental Alternation Test	7
	Mental Control Tests	6
Executive Functioning	Color Trails 2	22
	Stroop Color and Word Test	11
	WCST-64	10
	Rey Complex Figure	4
	Symbol Digit Modalities	1
Learning	HVLT-R	15
	BVMT-R	12
	WHO-UCLA	6
	Botswana Auditory Verbal Learning Test	1
Memory	HVLT-R	15
	BVMT-R	12
	WHO-UCLA	6
	Botswana Auditory Verbal Learning Test	1
Verbal Fluency/ Language	Category Fluency Nouns/Animal and fruit vegetable fluency/Semantic Fluency Verbs	14
	Letter Fluency	8
	Action Fluency (Verbs) /Category Fluency Verbs	5
Motor Functioning	Grooved Pegboard	23
	Finger Tapping	11
	Timed Gait	7
	Successive Finger Tapping	1

Abbreviations: WAIS-III: *Wechsler Adult Intelligence Scale*, WMS-III: *Wechsler Memory Scale*, PASAT: *Paced Auditory Serial Addition Test*, WCST-64: *Wisconsin Card Sorting Test*, HVLT-R: *Hopkins Verbal Learning Test Revised*, BVMT-R: *Brief Visuospatial Memory Test Revised*, WHO-UCLA: *World Health Organisation-University of California Los Angeles*

Table 4.

Screening Tools for NCI Used Alongside Comprehensive Batteries in Sub-Saharan Africa

Author	Country	Screening Tool
Joska et al. (2016)	South Africa	IHDS MoCA MMSE SSQ CAT-rapid
Kelly et al. (2014)	Malawi	IHDS
Robbins et al. (2017)	South Africa	NeuroScreen
Royal et al. (2016)	Nigeria	IHDS
Sacktor et al. (2009)	Uganda	IHDS
Yechoor et al. (2016)	Uganda	CogState Brief Battery

Note: IHDS = International HIV Dementia Scale, MoCA =Montreal Cognitive Assessment, MMSE=Mini Mental State Exam, SSQ=Simioni Symptom Questionnaire, CAT-rapid=Cognitive Assessment Tool-rapid