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Selection of cognitive impairment screening tools for longitudinal implementation in an HIV clinical care setting

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ABSTRACT

To address and slow the increasing burden of cognitive impairment in people surviving to older ages with HIV requires longitudinal monitoring of cognition. We conducted a structured literature review to identify peer-reviewed studies employing validated cognitive impairment screening tools in adult populations of people with HIV. We identified three key criteria for selection and ranking of a tool: (a) strength of validity of the tool; (b) acceptability and feasibility of the tool; (c) ownership of the data from the assessment. From our structured review of 105, 29 studies met our inclusion criteria, within which 10 cognitive impairment screening measurement tools were validated in a population of people with HIV. The BRACE, NeuroScreen and NCAD tools were ranked highly when compared with the other seven tools. Additionally, patient population and clinical setting characteristics (such as availability of quiet space, timing of assessment, security of electronic resources, and ease of linkage to electronic health records) were included in our framework for selection of tools. Numerous validated cognitive impairment screening tools are available to monitor for cognitive changes in the HIV clinical care setting, detecting opportunities for earlier intervention to reduce cognitive decline and preserve quality of life.

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Introduction

Effective antiretroviral therapy (ART) for HIV infection enables longer survival and was the recommended treatment for HIV-associated dementia HAD (Nweke et al., 2022). Cognitive impairment in PLWH is heterogeneous in presentation and severity, ranging from mild (asymptomatic neurocognitive impairment) to severe (HIV-associated dementia), with prevalence ranging from 33% to 12%, respectively (Kranick & Nath, 2012; Uwishema et al., 2022). Prior to effective ART, HAD was present in approximately 50% of PLWH; this burden has decreased to approximately 2% (Saylor et al., 2016). HAD continues to remain a highly prevalent issue in resource-limited settings with no access to ART (close to 50%) (Nightingale & Winston, 1992; Calcagno et al., 2021) however, cognitive impairment exists in all settings regardless of ART access (Uwishema et al., 2022). The pathophysiological mechanisms for cognitive impairment in PLWH remain elusive and confounded with individual- and neighborhood-level characteristics (Kolson & Buch, 2013). Cognitive impairment negatively impacts health (Kolson & Buch, 2013) and activities of daily living including bathing, medication responsibility, and shopping (Lee et al., 2019), ultimately reducing quality of life for people with HIV and cognitive impairment.

Although current HIV treatment guidelines recommend referral to a neurologist for "evaluation and management or neuropsychologists for formal neurocognitive testing" if a person with HIV is exhibiting "progressively worsening symptoms of HIV-associated neurocognitive disorder (HAND)", there are no recommendations for longitudinal screening for cognitive impairment in people with HIV (HIV and the older person: NIH, 2019). Integrating longitudinal screenings for cognitive impairment into routine care (similar to vital signs) enables clinicians to detect changes in cognition and intervene for earlier diagnosis-related assessments and interventions to reduce cognitive decline and preserve quality of life (Kolson & Buch, 2013).

Neuropsychological test batteries are the gold standard for diagnosing cognitive impairment (Zgaljardic & Temple, 2010). These tests are heterogeneous in nature, but are the "gold standards" for measurements of the cognitive domains of attention, language, memory, spatial, and executive function (Zgaljardic & Temple, 2010). There are barriers to longitudinal use of these batteries in

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PLWH (Wilson et al., 2021). First, some of these batteries are time- and expertise-intensive and not usually feasible for use in the context of routine clinical care (Wilson et al., 2021). There are shortened and modified versions of these batteries used to screen for cognitive impairment, however, many of which are now available for administration using electronic devices. Second, both neuropsychological test batteries and screening tools must be calibrated for the younger and heterogeneous socioeconomic status of PLWH. For example, the Montreal Cognitive Assessment (MoCA) underestimated the burden of cognitive impairment in PLWH (Mwangala et al., 2018; Rosca et al., 2019). The Brain Baseline Assessment of Cognitive and Everyday Functioning (BRACE) has performance differences based on the patient's education, drug use, and age (Rubin et al., 2021).

As individuals with HIV continue to age, longitudinal screening for cognitive impairment assessed during clinical care visits can provide information clinicians need for care decision-making. Criteria are needed to guide clinical directors in selecting the most appropriate cognitive impairment screening tool for implementation in their HIV clinical setting and for their patient population; currently, there is no guidance on this topic. The objective of our study is two-fold: (1) to review cognitive impairment screening measurement tools that have been validated in populations with HIV; and (2) identify criteria to guide decision-makers in the selection and longitudinal use of these tools in HIV clinical care.

Materials and methods

We conducted a structured (albeit, not systematic) review of the recent literature published in 2005–2021 to identify cognitive impairment screening tools that have been validated in PLWH. We searched PubMed using MeSH terms ([HIV] [cognitive tool] [cognitive impairment]). Title and abstracts were reviewed by a single reviewer for validation of the cognitive impairment screening tool in adult populations with HIV (compared to measurements of the cognitive domains of attention, language, memory, spatial, and executive function using gold standard neuropsychological test batteries). If there was confusion as to whether the tools were validated, a second reviewer and/or third reviewer was consulted until consensus was reached. In consultation with our clinician co-authors, we then identified three criteria relevant to assessing strengths and weaknesses of each tool with regard to implementation in an HIV clinic. We gathered descriptive information for each tool relevant to the criteria via websites from, and direct contact with, the companies that produce the tools. Then, the quality and strengths of each cognitive measurement tool were assessed by co-authors based on the identified criteria and ranked in order from 1 (most strengths) to 10 (fewest strengths) for the HIV clinical and research settings.

The evaluation of the cognitive impairment screening tools with our clinical co-authors resulted in discussions of how criteria to assess the tools are helpful, but the application of the criteria will differ by various HIV clinical populations and settings, rendering the rankings of the tools helpful but not sufficient to fully inform clinical directors' selection of a tool. Based on our review of the and our experience with such tools administered in the HIV clinical setting, we expanded our approach to include patient population, clinical setting, and technological characteristics that should be considered when selecting the most appropriate cognitive impairment screening tool for implementation in a specific HIV clinic. Finally, we summarized our framework into a list of questions for clinical directors' to answer to guide their decision-making process when selecting a cognitive impairment screening tool for longitudinal implementation in their HIV clinic.

Results

Search results from the MeSH terms and associated "Related Articles" returned 105 studies (Figure 1). After screening study titles and abstracts, 29 studies met our criteria. Upon in-depth review, 9 studies were excluded based on our criteria. Within the 20 studies that met our inclusion criteria, 14 cognitive impairment screening tools were employed. Among these 14 tools, 4 lacked validation against gold standard neuropsychological test batteries in populations with HIV and were excluded.

Criteria for comparing of cognitive impairment screening tools

Among the 10 tools meeting our inclusion criteria, 4 were computerized, 3 were tablet- or smartphone-based, 3 were paper-based and interviewer-administered (Table 1). We identified the following three criteria for evaluation of the cognitive impairment screening tools: (a) strength of the validity of the tool in populations with HIV; (b) feasibility of implementation of the tool; and (c) ownership of the data from the assessment. The validity of the tools against gold standard neuropsychological test batteries among PLWH varied. BRACE, NeuroScreen, CogState, CSCT, and IHDS all had relatively high sensitivities of over 80% (84%, 90%, 81%, 81%, 91%, respectively). NCAD (67%), CAMCI (72%), MoCA (69%), CAT-Rapid (64%), and MMSE (46%) had lower sensitivities.

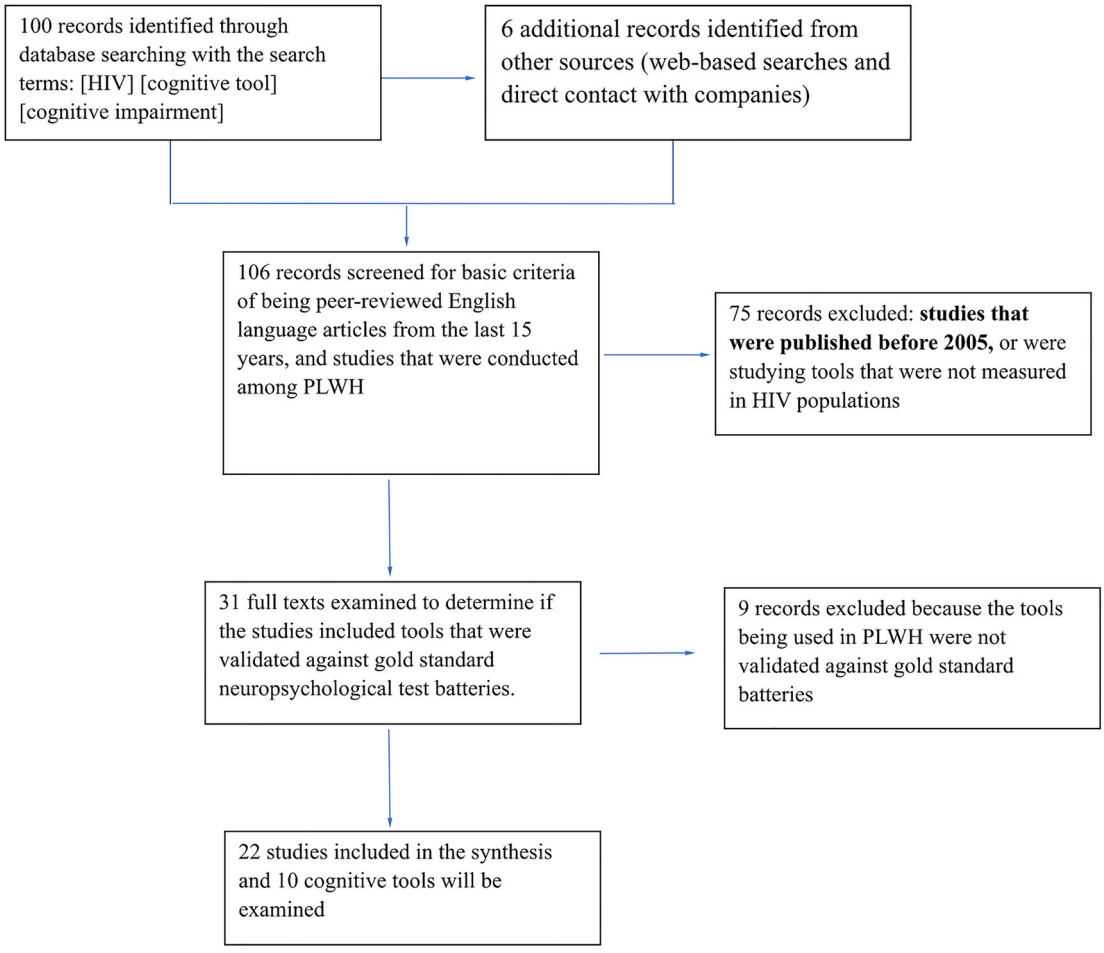

Figure 1. Identification strategy for studies included in this review.

BRACE, CAMCI, and NCAD had the highest specificities with 94%, 97%, and 83% (respectively). NeuroScreen (63%), CogState (70%), CAT-Rapid (52%), CSCT (53%), MoCA (58%), MMSE (55%), had lower specificities, and IHDS had the lowest specificity of 17%.

Acceptability and feasibility was the second criteria used to assess the 10 cognitive impairment screening tools. The studies employing computerized and tablet-based tools reported high acceptability by patients (Anderson et al., 2016; Becker et al., 2011; Cysique et al., 2006; Joly et al., 2020; Maruff et al., 2009; Robbins et al., 2014; Rubin et al., 2021). Two of these tools required less oversight by clinical staff and provided more privacy for the patient when responding (Anderson et al., 2016; Becker et al., 2011). NeuroScreen, specifically, conducted a survey with patients and clinicians following their assessment which reported that 93% of the sample reported feeling "very comfortable" using the tool, 73% reported that the tool was "easy to use", and participants overall reported that they would not mind receiving a similar screening test during regular HIV care medical visits (Robbins et al., 2014). BRACE, NeuroScreen, CogState, MoCA, CSCT, NCAD, and CAMCI can all be adapted into different languages and have options for instructions to be read aloud, improving acceptability by patients. Similarly, IHDS, MMSE, and CAT-Rapid do not require knowledge of the English language and can be administered by people of varying educational backgrounds.

Finally, ownership of data from the assessment was considered; this criteria is particularly relevant to ensuring the assessment results are available in the electronic health record so that they can inform clinical decision-making. MMSE, IHDS, and CAT-Rapid are interviewer-administered, paper exams; calculation of the score is performed by the interviewer after the test is completed. Resources are required to assess the accuracy of the calculated score and establish an electronic health record-nested form to uptake the date, time, interviewer, and score into the electronic health record. All the other cognitive impairment screening tools reviewed were technology-administered, automatically scored, and included data security for results. NCAD, BRACE, CogState, CAMCI, CSCT and MoCA utilize unique data

Table 1. A comparison of tools to measure cognitive function that have been validated in populations of people with HIV.*

Rank	Cognitive Assessment Tool	Type of Data Collection Tool	Validity against Gold Standard NP Test Battery	Feasibility within Clinical Flow	Ownership of Data Collected	Additional Comments
1	Brain Baseline Assessment of Cognition and Everyday Function (BRACE) (Rubin et al., 2021)	iPad-based cognitive impairment screening tool 4 NP tests: Trail Making Test A&B, Stroop-color test, visual- spatial learning test 12 min for completion (includes collection of sociodemographic data for norming, rapid color blindness assessment, PHQ-2, and 5 item self-report subjective cognitive complaints)	Test had acceptable test–retest reliability after 4 weeks ($r = 0.81$) and 6 months ($r = 0.84$); no practice effects noted, criterion validity-association between BRACE and NP tests = 0.63, $P < 0.001$, 84% sensitivity 94% specificity	Tests are not literacy dependent – allows for use within low education populations Easily adaptable to different languages (currently in use in Uganda) iPad allows for self-administration, and minimal training High acceptability by patients	Clinically relevant data sent to clinicians Researchers can access results through secure transfer of data, data is wiped from device as soon as assessment is complete Assessments scored automatically, and reports available weekly Patient Health Information is secured: assessments utilize secure IDs and information about age, sex, race/ethnicity, and education	Normative data at present is only based on 144 HIV uninfected individuals Participants were volunteer- based, potential generalizability issues
2	NeuroScreen (Robbins et al., 2014)	Software application for smartphones using Android operating system NeuroScreen assessed six NP domains with 10 tests 25-minute exam	50 PWH administered gold-standard NP test battery Sensitivity ~90%, specificity ~63% High correlation between NeuroScreen and gold standard test battery	High level of acceptability by patients Easily adaptable to different languages No additional equipment required; scoring is done automatically - allows for easy integration with electronic medical records Surveyed providers believed it would be a useful addition to clinical care and could be incorporated into their practices	Data is immediately transferred to PI's secure and encrypted hard drive, and then all data were wiped from the device Only the participant ID and handedness were entered in the app	Providers indicated that a tablet version would be easier to use Findings need replication in a larger, non- convenience sample and compared to normative data with HIV-negative individuals
3	Novel Computerized Cognitive Assessment Device (NCAD) (Anderson et al., 2016)	Participant wears headset unit with video display and noise-canceling headphones 20 min assessments with automated voice-overs Assesses 4 domains: processing speed, episodic memory, working memory, executive function (word recall, sequential colored shapes, colored arrow direction, faces)	Compared to NP test battery: 67% sensitivity, 83% specificity	Completely automated – minimizes test administration variability Immediate digital storage and data interpretation Requires adequate vision and ability to hold and operate keypad (those with severe visual impairment and impairment in manual dexterity can't use assessment) Straight forward for clinic staff to administer	Use iDETECT for reliable data upload Results uploaded immediately after completion, individual de-identified scores are available for review on password- protected website	Participants had long histories of HIV – researchers want to measure again in patients with shorter HIV history without severe immunocompromise Functionality of assessment needed for official HAND diagnosis Product is not yet in commercial production
4	Computerized Assessment of Mild Cognitive Impairment (CAMCI) (Becker et al., 2011)	Duration: 15–20 min Asks demographic data as well as assessments for attention, memory, executive function, and psychomotor speed	Sensitivity of 72%, specificity of 97% CAMCI has been found to identify the same individuals who are likely to have impaired performance on a more detailed test battery	People with minimal or no computer background can easily complete the assessment Tests presented visually and aurally, administered using a modified tablet computer with touch-screen for response input Much less refusal by patients than traditional NP test batteries	Immediate reports are available, assessments are automatically scored Security preferences can be set for viewing and assessing data	Has functionality tasks in addition to neuropsych (i.e. grocery shopping task) Tablet-based, run at patient's own pace, ensures standardized administration and scoring
5	CogState Brief Battery (Maruff et al., 2009; Cysique et al., 2006)	Computerized assessment on desktop computer (Cysique et al., 2006) Eight tasks in the form of card games measuring 4 cognitive domains: psychomotor speed, visual attention, executive function, and memory (Cysique et al., 2006)	Test had acceptable construct and criterion validity in NP context (Maruff et al., 2009) Sensitivity 81.1%, Specificity 69.9% (Cysique et al., 2006)	Computerized test makes it easy to administer and track data Necessary to have access to desktop computers, which may not be as cost-effective	Researchers can immediately access results allowing for efficient review, cleaning, and analysis CogState Research includes its own secure cloud-based online data management (Cogstate, 2022)	Data from convenience samples (Maruff et al., 2009) Tests were brief, so difficult to receive information about how the tasks were performed (Maruff et al., 2009)

(*Continued*)

Table 1. Continued.

Rank	Cognitive Assessment Tool	Type of Data Collection Tool	Validity against Gold Standard NP Test Battery	Feasibility within Clinical Flow	Ownership of Data Collected	Additional Comments
		10–15 mins for completion (Cysique et al., 2006)				
6	The Montreal Cognitive Assessment (MoCA) (Aita et al., 2021; Rosca et al., 2019)	10-minute cognitive screening tool to assist in detection of mild cognitive impairment, a clinical state that often progresses to dementia (Rosca et al., 2019) Assesses 5 domains: short term memory, visuospatial abilities, executive functions, attention/con centration, and working memory (Rosca et al., 2019) App and Paper Versions Exist	MoCA detected mild AD with 69% sensitivity, 58% specificity (Aita et al., 2021)	Needs extensive cultural adaptation to be suitable for linguistically, culturally, educationally, and economically diverse populations (Mwangala et al., 2018) Some patients felt it was not difficult enough to actually measure their cognition	MoCA app generates reports as soon as assessment is completed which can be uploaded to patient medical records (app and reports are password protected) (*MoCA Cognitive Assessment – Digital Tools,* 2022) Each patient has a unique MoCA file that is held only by the institution (*MoCA Cognitive Assessment – Digital Tools,* 2022) Minimal patient identifiers are collected (age, sex, education) (*MoCA Cognitive Assessment – Digital Tools,* 2022) Data is stored on Microsoft corporation server (*MoCA Cognitive Assessment – Digital Tools,* 2022)	Comparative results in both academic and community settings (Mwangala et al., 2018)
7	CAT-Rapid (Joska et al., 2016)	Paper-based, interviewer administered exam Included four symptom questions, registration of four words, mini-trail-making test of four letter/number pairs, and word recall Duration: 7 min	Overall Specificity of 52%, differing sensitivities based on measurements (normal vs. HAND – 64%, normal vs. HIV-D 94%)	Quick and short assessment	N/A Paper-based	Useful in screening for HIV-D, combined with IHDS was even more sensitive (89%) and specific (82%), but not as good for HAND, i.e. can't detect mild cognitive impairment as successfully
8	Computerize d speed cognitive test (CSCT) (Joly et al., 2020)	Computerized version of SDMT (symbol digit modality test) Duration: 2 min Patient has to associate number with symbol by referring to a model –> answers given orally (allows control of motor processing speed that could be impaired)	81% sensitivity, 53% sensitivity Cutoff scores for measuring HAND with this assessment is unknown	Administration can occur by any medical provider (doesn't have to be a psychologist) Simple and short examination, high acceptability by patients	System automatically calculates performance score, no personal data is recorded by system	Can't discriminate mild forms of HAND Just an initial form of screening, can only assess if HIV patients require more thorough cognitive evaluation
9	The International HIV Dementia Scale (IHDS) (Sacktor et al., 2005)	Consists of three sub- items: timed finger tapping, timed alternating hand sequence test and a 2-minute delayed recall of four words Interviewer-administered exam	Compared to an NP test battery: sensitivity 91%, specificity 17%	Does not require knowledge of English language Can be performed by non-neurologists in outpatient setting (ideal for international setting where resources are limited) Useful for those with and without a complete high school education	N/A Exam is not computerize d; it is completely administered by a trained professional and scored immediately after Cutoff score used for determining potential dementia, and requires further evaluation	Not useful for detecting mild cognitive impairment associated with HIV Unable to distinguish between different stages of cognitive impairment Age and substance use are possible confounders
10	Mini-Mental State Exam (MMSE) (Skinner et al., 2009)	Includes tests of orientation, attention, memory, language, and visual-spatial skills Interviewer- administrated exam, with some paper components Takes around 10 min to complete	Sensitivity 46%, specificity 55%	Easy administration – doesn't require much training or equipment Estimates stage and severity of dementia Education often a confounder	N/A Paper exam, requires knowledge of scoring the tests during administration, trained professional determines the total score Different scores correlate to different levels of dementia	Questions relatively simple, thus measures severe cognitive impairment only Age, education, and cultural background tend to bias scores

Notes: * The citation next to the name of the tool refers to all data in the subsequent columns. If more than one citation was used per tool, each data point is referenced separately.

management systems where reports are uploaded regularly to secure cloud platforms. These reports do not utilize patient identifiers, are password-protected and can be automatically transferred to the EHR; however resources to link the unique identifier from the assessment to the patient are required. The assessment results from the NeuroScreen tool are transferred directly to a local secure hard drive for analysis and scoring; resources are needed to link the results in the local hard drive to the electronic health record. Important to reducing risks to data security, all of the electronically-administered tools did not store (or had automated deletion capabilities for) assessment results on the local electronic device the patient used to complete the assessment.

Additional considerations when selecting a cognitive impairment screening tool: patient population and clinical setting characteristics

We identified two key characteristics of the patient population that should be considered when selecting a tool (Table 2): social determinants of health and physical impairments. The most important clinical and technological characteristics for consideration when selecting a cognitive impairment screening tool include: (a) quiet space to complete the assessment; (b) time for the patient to complete the assessment without disruption to clinical flow; (c) availability and security of the electronic resources needed to administer many of these tools; (d) resources to link the results of the assessment to the electronic health record (Table 2).

Questions to guide tool selection decision-making

We developed a list of questions to guide clinical director decision-makers and researchers when selecting a tool to monitor cognitive impairment in the HIV clinical setting (Figure 2). These questions were developed to match the strengths of the cognitive impairment screening tool to the patient population and clinical characteristics within which it will be implemented.

Discussion

We propose the following framework to guide clinical directors when selecting a cognitive impairment screening tool for longitudinal use in their HIV clinical setting that includes considering the characteristics of the: (1) cognitive impairment screening tools validated in populations with HIV; (2) clinical population; and (3) clinical setting. We identified cognitive impairment screening tools validated among people with HIV, which expands upon a systematic review of digital cognitive impairment screening tools in populations with HIV (Wilson et al., 2021). The only discrepancies between our list of tools include EMA (this tool is not available on the market and thus we did not see it fit to include it as part of a list of recommendations) and CalCAP (this tool only has one validation study, and thus we also did not see it fit to include at this time). Perhaps more importantly, we described the characteristics of each tool that may influence the selection of these tools, including (a) strength of validity of the tool (compared to neuropsychological test batteries) among populations with HIV; (b) feasibility of implementation of the tool; and (c) ownership of the data from the assessment. We identified important social determinants of health and physical impairments that should be considered when looking at the patient population in which the tools will be administered as well as different clinical setting and technological considerations. Finally, we propose four questions for initial consideration to support clinical directors initiating the process to select a

Table 2. Clinical characteristics to be considered when choosing/developing a screening tool.

Patient Population Characteristics		Clinic Setting Characteristics	Technological Considerations
Social Determinants of Health	Physical Impairments		
Current and former drug use	Visual impairment (color-blind, health-related impairment)	Quiet space in clinic to complete the assessment	Availability of electronic resources needed to administer the tools • Access to WiFi • Access to a sufficient number of technological devices • Access to headphones for audio-based instructions • Access to stylus pen for physically impaired patients
Low educational background	Physical impairment (arthritis, long finger nails)	Sufficient time for the patient to complete the assessment without disruption to clinical flow	Resources to ensure the connectivity of the data collected to the patient's electronic health record
Age of patient	Comfort with use of technology	Support staff to secure the technology	

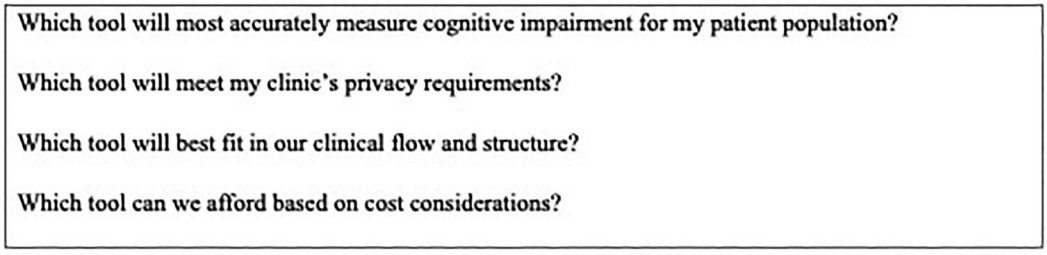

Figure 2. Questions to guide clinical director's and researcher's decision-making when selecting cognitive impairment tools for implementation in an HIV clinical setting.

cognitive impairment screening tool for longitudinal implementation in their HIV clinic. Implementation of such tools can provide timely measurements of cognitive changes, identifying opportunities for earlier intervention and preserve quality of life among adults with HIV. As evident by the inclusion of a developmental indicator for measuring quality of life among older adults with HIV in the *US National HIV Strategy*, longitudinal cognitive impairment screening is critical for caring for adults with HIV (National HIV/AIDS Strategy [2022–2025], 2021).

The NIH has developed a Toolbox for the Assessment of Neurological and Behavioral Function, which includes brief assessments that measure motor, emotional, sensory, and cognitive function in people aged 3–85 (*NIH toolbox. Nation Institute on Aging.)*. Although Toolboxes are helpful in identifying available tools, validation of the tools specific to clinical populations, and criteria to guide selection of such tools, is needed. When we evaluated the characteristics of the cognitive impairment screening tools validated in populations with HIV (the first consideration in our proposed framework), we found many of the tools under-estimated of cognitive impairment in populations with HIV. This highlights the necessity of longitudinal measurements; change in cognitive impairment should be insulated from this under ascertainment, assuming the under-ascertainment is constant over time. Although the integration of many cognitive impairment screening tools to electronic platforms may increase the feasibility of administration in some settings, availability of electronic devices, internet connections, software problems, the various methods in which results are returned and the resources needed to integrate the results into the electronic health record may make them difficult to use in many settings (Wilson et al., 2021). Ideally, the tools become self-administering, or become as integrated in a care visit as routine vitals (Herrmann S. R. et al., 2019), however, the time, infrastructure, technological, and financial resources needed to implement the tool must be secured for successful implementation. Piloting the tool, is recommended, as is an evaluation of the tool's performance in detecting changes in cognitive impairment within the patient population.

The proposed two characteristics for the patient population must be considered to select the most appropriate cognitive impairment screening tool. First, our evaluation of the validity of the tools revealed the distribution of social determinants of health within the patient population impacted a tool's performance. Patient populations with a high proportion of people who currently or previously used drugs, or with less than high school educational attainment, need tools that have been validated in similar populations with HIV or have methods to calibrate results to these population characteristics; BRACE and MoCA have these features (Rubin et al., 2021). Second, the proportion of patients with physical impairments should be considered. Visual or hearing impairments must be considered, and accommodations made, including assisted administration which requires staff availability. Arthritis and long fingernails (for esthetic purposes) can make the use of certain technological tools more difficult, which may be overcome with aids, such as stylus pens, or assisted administration.

Clinical characteristics must also be considered when selecting a cognitive impairment screening tool. If the cognitive impairment screening tool is administered while the patient is at the clinic, a quiet space is needed for the completion of the assessment. There needs to be sufficient time in the patient's appointment schedule to allow the patient to complete the cognitive impairment assessment, the results to upload to the electronic health record, and the provider to access the results during the visit. If the assessment is administered during the clinic visit as they wait for their healthcare provider, the quiet space location should be located close to the waiting room to reduce the time it takes for staff to find patients when the provider is ready to see them. Sufficient technological resources are also needed to administer the assessment, including the electronic devices themselves

(tablets or desktop computers), internet connection, and stylus pens and headphones (to assist patients with impairments). Clinical or security staff are needed to monitor the electronic devices and ensure they are secured and charging during non-clinic hours. Finally, each cognitive impairment screening tool has its own capabilities for integration of the results into the patient's electronic health record. Consultation with the team that administers the clinic's electronic health record system will be required to estimate the resources needed to ensure results are added to the electronic health record in a timeline manner to be useful for clinical decision-making.

There are limitations to our descriptions of validated cognitive impairment screening tools in people with HIV and our proposed framework. We did not perform a systematic review of cognitive impairment screening tools, but rather, we expand upon previous systematic reviews (Kamminga et al., 2013; Wilson et al., 2021; Zipursky et al., 2013) and build a broader framework for selecting the most appropriate tool for the patient population and clinical setting. We drew upon our direct experience with patient populations and implementation of cognitive impairment screening tools to determine the three most important criteria to consider when evaluating the tools, but other criteria may be setting specific and not included in our framework. The rankings assigned to the tools are subjective; they are meant to identify the tools with the greatest benefits according to the criteria upon which they were evaluated. Similarly, the patient and clinical setting characteristics we identified for consideration are also from our review of the tools and our direct experience; other setting-specific criteria are not included. The scope of our study is in the selection and implementation of a cognitive impairment screening tool and does not include the resources and workflow for referral of patients to additional neuropsychological testing for diagnosis and treatment. Future evaluation of optimal implementation, as well as impact on patients, is needed as longitudinal data from the use of these tools in the clinical setting are generated, or new validated tools for PLWH emerge.

We propose a framework for clinical directors to evaluate and select cognitive impairment screening tools best suited for their patient population and clinical setting. As the burden of cognitive impairment continues to grow with ageing populations living with HIV, with increasing downstream effects on quality of life, longitudinal screening for cognitive impairment can provide the necessary information for clinical decision-making and earlier intervention when caring for older adults with HIV.

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