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Concurrent Validity of a Computer-Based Cognitive Screening Tool for Use in Adults with HIV Disease

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Abstract

As the incidence of HIV-associated dementia has decreased, the survival of HIV-infected individuals with milder forms of cognitive impairment has increased. Detecting this milder impairment in its earliest stages has great clinical and research importance. We report here the results of an initial evaluation of the Computer Assessment of Mild Cognitive Impairment (CAMCI®), a computerized screening tool designed to assess abnormal cognitive decline with reduced respondent and test administrator burden. Fifty-nine volunteers (29 HIV infected; age = 50.9 years; education = 14.9 years; 36/59 males) completed the CAMCI® and a battery of neuropsychological tests. The CAMCI was repeated 12 and 24 weeks later. The results from the CAMCI were compared to Global and Domain Impairment scores derived from the full neuropsychological test battery. The CAMCI detected mild impairment (compared with normal and borderline test performance) with a sensitivity of 0.72, specificity of 0.97, positive predictive rate of 0.93, and a negative predictive rate of 0.89. Median stability over 12 and 24 weeks of follow-up was 0.32 and 0.46, respectively. These rates did not differ as a function of serostatus. A discriminant function analysis correctly classified 90% of the subjects with respect to their overall Global Impairment Rating from six of the CAMCI scores. This preliminary study demonstrates that the CAMCI is sensitive to mild forms of cognitive impairment, and is stable over 24 weeks of follow-up. A larger trial to obtain risk-group appropriate normative data will be necessary to make the instrument useful in both clinical practice and research (e.g., clinical trials).

Introduction

In countries with generally good access to medical care, HIV disease is evolving into a chronic medical condition. While the incidence of HIV-associated dementia has fallen with the use of highly active antiretroviral therapy (HAART),[1] the survival of HIV-infected individuals with milder forms of cognitive impairment has increased.[2] There can be waxing and waning of cognitive symptoms and the cognitive deficits can affect a range of activities of daily living.[3] Critically for this study, 52% of the participants from the CHARTER study had deficits in cognitive functions, and one third had asymptomatic neurocognitive impairment.[4]

The ability to identify this milder disorder in clinical practice is important, as it may be a harbinger of other changes in central nervous system (CNS) function. However, subtle changes in cognition (e.g., as in the asymptomatic or minor neurocognitive disorder[5]) are usually difficult for a patient to report—especially in the absence of a reliable informant, something that is common in the care of relatively young and relatively healthy patients with HIV disease. Thus, a tool that could be easily and quickly utilized in the context of an infectious diseases clinic for example might increase the ability of the treating physician to identify early changes in cognition (i.e., before they become obvious to the patient), modify the treatments if indicated, and then monitor change over time. In the context of clinical or pharmacologic research, it is equally important to have a tool that can reliably monitor cognitive functions over relatively brief periods of time generally used to assess safety and efficacy (i.e., 12, 24, 48 weeks).

Neuropsychological tests traditionally have been "pencil and paper" assessments, but during the past 15–20 years a number of computerized tests have been developed.[6] In the context of a busy primary care physician (PCP) or infectious diseases clinic, the use of computerized tests as screening tools for more detailed assessments has the potential advantage of

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being able to be administered by a nurse or other physician extender, and still provide meaningful information with regard to the risk of true cognitive impairment. If such a computer assessment used tablet computers, this could provide an improvement over larger desktop or laptop machines. Tablets are small, lightweight, portable, easy to use, and employ touch-screen and/or pen stylus technology, which is easier to use than a mouse for novice computer users or those with peripheral sensory/motor limitations.

The Computer Assessment of Mild Cognitive Impairment (CAMCI®) is a brief, standardized, computer-based assessment of mental status that was designed to be used by health care professionals to detect mild abnormalities in cognition.[7,8] The CAMCI asks about demographic data to document orientation to time, person and place; briefly assesses the presence of depression, anxiety and alcohol use; questions the patient about their perceived everyday memory problems; and assesses attention, verbal and nonverbal memory, working memory, long-term memory, executive function, and psychomotor speed—all within 15–20 min. The CAMCI has been evaluated to date primarily for its utility in older adult populations and its ability to discriminate between older adults with mild changes in cognition and healthy elderly.[7] Persons with minimal or no computer background can easily complete the assessment.

Because the CAMCI is user-friendly, and is seen as less obviously cognitively demanding (based on the nature, not the difficulty of the tasks), it may provide an important tool for the evaluation of cognitive functions in HIV disease. This is not simply limited to routine evaluation within the context of the PCP or infectious diseases clinic—where a "positive" outcome would lead to a clinical referral. The CAMCI also may be useful in evaluating outcomes of various therapeutic interventions aimed at reducing or eliminating the cognitive deficits associated with HIV disease (or screen for neurotoxicities). The purpose of the present report is to describe a small-scale, preliminary study of the relative merits of the CAMCI in detecting mild cognitive impairments in persons at-risk for, or having HIV infection. In addition, we retested all of the individuals after 12 and 24 weeks of follow-up, providing information about the stability of the test measures over time.

Methods

Overview

Sixty subjects were enrolled in this study; 30 HIV-infected and 30 HIV-seronegative controls all were participants in a preliminary study of a cognitive stimulation program (unpublished data). Each subject received a neurobehavioral evaluation at study entry and was reevaluated after 12 and 24 weeks of follow-up. One subject could not complete the CAMCI at study entry due to a hardware problem, and thus the data from only 59 participants are included in this report.

Inclusion criteria. Inclusion criteria included age 40–65 years; native language English; no history of neurologic disease, CNS opportunistic infections, CNS tumors, or stroke; no history of learning disability or attention deficit disorder/attention deficit hyperactivity disorder (ADD/ADHD; by subject report). Each subject underwent a semistructured diagnostic interview including the mood and substance use disorders modules from the Structured Clinical Interview for DSM-III-R[9] and were excluded from the study if they had evidence of active drug/alcohol abuse or dependence or a current major depression.

Instruments

Neuropsychological test battery. These tests were administered by trained examiners at study entry and after 24 weeks. These included measures of memory, language, visual–construction, psychomotor speed, motor and executive functions. Neuropsychological test performance was indexed by the Global Impairment Rating.[10] The individual test scores reflecting eight cognitive domains were transformed into T-scores that were adjusted for age, education, gender, and race,[11,12] and clinical ratings ranging from 1 (above average) to 9 (severe impairment) were assigned to each domain (Domain Impairment), and to each subject at each study visit (Global Impairment Rating).[10] The Domain and Global ratings were assigned using a specific algorithm described in detail by Woods and colleagues.[10]

CAMCI

Because the CAMCI was originally designed for elderly individuals who may not be comfortable with computers, it uses a response format that is no more complex than choosing which keys to press on a telephone, and the test battery runs on a tablet computer. The development of the CAMCI tests was guided by two general approaches. First, the standard approach to neuropsychological tests of attention, executive abilities, working memory, and verbal and visual memory was modified so that tests could be administered on a computer. Each of the modified tests is scored for both accuracy and reaction time. Second, virtual reality technology was used to develop a test in which the individual moves through a virtual world on a shopping trip resembling an everyday experience embedding memory tests, executive function tests, and speeded performance.

The CAMCI takes approximately 20 min to complete and all tests are presented both visually and aurally. The CAMCI is administered using a modified tablet computer (Motion Computing J3400 Tablet PC, Motion Computing, Austin, TX), with a touch-screen for response input. The CAMCI includes eight subtasks testing multiple cognitive domains (attention, verbal memory, nonverbal memory, incidental memory, executive function, and processing speed), and a series of self-report questions regarding memory loss, alcohol use, depression, and anxiety. The scores are adjusted for age and education level to produce normative T-scores. Domain and task level data based on accuracy and reaction times are also reported.

Star Task (attention). The participants are shown a star, circle, square, or triangle and told to tap the screen as quickly as possible only when the star appeared. This task is similar to a simple reaction time test.

Forward Digit Span (attention). A series of three to six digits are presented at a rate of one per second. After presentation, participants must recall the digits in the correct order using the display at the bottom of the screen.

Word Recognition (verbal memory). A list of six words is shown on the screen, one at a time. The participant is in-

structed to remember each word and told that they will be asked to recall it later. After a delay, six sets of four words (three distracters and the target word) are displayed and the task is to tap the target word.

Word Recall (verbal memory). Participants are presented with a list of 5 three-letter words (e.g., spy, bat) one at a time and told to remember them. The lists are presented three times, with the words in random order. Approximately 10 minutes after the learning phase, the subject is asked to recall each of the five words by typing them on a keyboard that appears at the bottom of the screen.

Picture Recognition (visual memory). The participant is shown a series of pictures in a fixed order. Some of the pictures are repeated in the series and some are not. The subject must tap "yes" if the picture has been shown previously and "no" if it has not.

Go/No-Go Test (executive function). In part 1 of this task, participants must tap the screen twice when they hear one "beep" from the computer, and once when they hear two beeps. In part 2 the rules are changed and participants are told to tap twice when they heard one beep and do nothing when they heard two beeps. This test is similar to the bedside examination used by Luria to evaluate response flexibility, perseveration, and other frontal system functions.

Digit Reverse Span (working memory). This task is identical to forward digit span except that participants are told to recall the digits in reverse order.

CAMCI® Shopping Trip/Virtual Reality. The participants navigate through a virtual world on the tablet computer. They are told they are driving to a store to purchase several items and on the way they must run several errands such as stopping at the bank and the post office. Within the virtual world task, there are a number of cognitive domains that are assessed. These are:

Recognition memory. The participant is shown a list of grocery items (i.e., bread, bananas, donuts, and shampoo) and told that these are the items he/she wants to purchase at the store. At the end of the shopping trip the participant is shown a series of pictures including the target items and told to tap the picture of the items they were told to purchase.

Incidental recall. During the shopping trip the participant passes several objects including a sedan car, a city bus, and a boy on a bicycle, but is not warned in advance that they must remember them. After the trip the participant is presented with a series of pictures and told to tap on the ones that appeared during the test.

Prospective memory. At the beginning of the shopping trip the participant is told that on the way to the market they must stop at the bank to transfer money, and must stop at the post office to mail a letter. The participant is told to tap on the image of the bank and the post office when they appear on the screen to indicate that they have remembered to perform these tasks.

Shopping trip choice points. At the beginning of the shopping trip the participant is provided with directions to the store, e.g., "Make a left on Fir Street, then make a right on Ash Street." The directions remain on the screen throughout the test so the participant can refer to them at any time. At each intersection the participant has to decide which direction to go.

Bank machine. When the participant arrives at the bank he/she sees a standard bank automatic teller machine. The participant is told to transfer $250.00 from the savings account to the checking account. Each step of the transaction is scored for correctness and the time taken to complete the task. If the participant does not remember to stop at the bank, the CAMCI automatically "drives" to the bank so that this portion of the test is completed.

Post office. The participant is told before the start of the virtual reality shopping trip that they need to drop off a letter at the post office mailbox. During the drive, the participant is to remember to tap on the post office sign, at which point the car turns into the post office parking lot and drives by the mailbox and the letter is "virtually" sent into the mailbox. If the participant does not remember to stop at the post office, the CAMCI automatically "turns" and delivers the letter.

Results

The characteristics of the study subjects are shown in Table 1 as a function of serostatus. Table 2 shows the results of the CAMCI as a function of the Global Impairment Rating from the baseline neuropsychological test battery. The subjects were classified as "normal" (ratings: 1–3), "Borderline" (rating: 4), or "impaired" (ratings: 5–9). There were no significant differences among the subjects in these three classifications as a function of age, education, gender, or serostatus. In addition, we completed a multivariate analysis of covariance on the CAMCI scores between serostatus groups (controlling for age), and there were no performance differences as a function of HIV infection ($F(14, 43) = 0.904$, $p > 0.05$).

Table 1. Baseline Subject Characteristics by HIV Status

Variable	*HIV−*	*HIV+*	*Group comparison, Statistic test and effect size*[a]
n =	30	29	
Age	50.7 (6.3)	51.1 (6.2)	0.21, 0.0009
Education	14.6 (2.5)	15.1 (1.9)	0.69, 0.012
Reading level (Wide Range Achievement Test)	11.1 (3.0)	11.7 (1.9)	0.75, 0.014
Gender (%[*n*] male)	77.8 (14)	95.7 (22)	3.0, 0.27
Race (%[*n*] white)	61.1 (11)	69.6 (16)	0.32, −0.09
Diabetes (%[*n*])	5.6 (1)	4.3 (1)	0.03, −0.03
Hypertension (%[*n*])	22.2 (4)	43.5 (10)	2.0, 0.22
Alcohol (%[*n*])[b]	50.0 (9)	43.5 (10)	0.17, −0.07
Drug (%[*n*])[b]	44.4 (8)	21.7 (5)	2.4, −0.24
Depression (%[*n*])[c]	61.1 (11)	47.8 (11)	0.72, −0.13
Global Impairment Rating	3.67 (1.9)	3.78 (1.9)	0.19, 0.0009
Global Symptom Index	.287 (.21)	.444 (.54)	−1.16, 0.03

[a] t, r^2 or χ^2, Phi. No test statistic reached $p < 0.05$.
[b] Lifetime history of abuse or dependence.
[c] Lifetime history of major depressive disorder.

Table 2. CAMCI® Scores as a Function of Global Impairment Ratings at Baseline

	Global impairment groupings			
	Normal	*Borderline*	*Impaired*	*Group comparison, test statistic and effect size*[a]
Number	26	15	18	
Age	52.3 (5.9)	49.7 (5.8)	50.5 (5.9)	1.05, 0.04
Education	15.6 (2.0)	14.5 (2.1)	14.2 (1.9)	2.98, 0.10
Gender (%[N] male)	85 (23)	93 (14)	78 (14)	1.55, 0.16
HIV serostatus	48 (13)	53 (8)	50 (9)	0.10, 0.04
Global Impairment Rating	2.30 (0.61)	4.00 (0.0)	6.17 (0.92)	191.4, 0.87[b]
CAMCI raw scores				
Star	8.9 (0.33)	9.0 (0)	8.8 (0.73)	0.96, 0.03
Trees	18 (1.5)	16.9 (2.2)	14.6 (4.3)	8.19, 0.23[b,d]
Verbal Memory	6.0 (0.20)	5.5 (1.2)	5.7 (.75)	2.19, 0.07
Executive Function 1	10 (0.20)	9.9 (0.35)	9.3 (1.0)	6.08, 0.18[b,d]
Executive Function 2	9.9 (0.33)	9.9 (0.52)	8.7 (3.2)	2.79, 0.09
Forward Span	5.9 (0.27)	5.8 (0.41)	5.7 (0.49)	2.39, 0.08
Reverse Span	4.8 (0.51)	4.8 (0.41)	4.1 (0.87)	8.39, 0.23[b,d]
ATM	6.5 (1.1)	6.5 (1.1)	5.3 (2.0)	4.69, 0.14[b,d]
Word Recall	4 (0.98)	3.3 (1.2)	2.6 (1.4)	7.44, 0.21[b,c]
VR Driving	17.4 (0.98)	16.6 (2.4)	16.8 (1.2)	1.37, 0.05
Item Recall	5.4 (0.90)	5 (1.5)	4.5 (1.4)	2.93, 0.09
Incidental Recall	2.7 (1.1)	2.6 (0.99)	2 (0.97)	2.52, 0.08
Bank	0.81 (0.40)	0.67 (0.49)	0.56 (0.51)	1.64, 0.06
Post Office	0.85 (0.37)	0.80 (0.41)	0.61 (0.50)	1.71, 0.06
CAMCI T-scores				
Attention	49.8 (8.9)	52.7 (0.98)	49.3 (10)	0.80, 0.03
Forward Span	53.4 (6.0)	50.8 (9.2)	47.8 (11)	2.24, 0.07
Reverse Span	52.8 (7.0)	53.3 (5.9)	42.9 (13)	8.24, 0.23
Go/No-Go 1	53.9 (1.0)	53.1 (2.9)	49.6 (7.3)	5.58, 0.17[b,c]
Go/No-Go 2	53.5 (1.6)	53.5 (2.9)	49.4 (11)	2.52, 0.08
Driving	56 (4.6)	52.9 (11)	53.6 (6.0)	1.22, 0.04
ATM	54.5 (5.4)	55 (6.6)	48.8 (10)	3.90, 0.12[b,c]
Words	56.2 (7.9)	51.1 (9.6)	45.8 (11)	6.55, 0.19[b,c]
Verbal Recognition	53.1 (4.7)	47.4 (14)	49.6 (10)	1.86, 0.06
Picture Recognition	55.4 (6.7)	50.6 (9.0)	43.5 (12)	8.93, 0.24[b,d]
Item Memory	56.4 (7.4)	52.9 (12)	49.3 (11)	2.74, 0.09
Incidental Memory	53.9 (10)	53.1 (9.6)	47.7 (10)	2.21, 0.07

[a]F and η^2 for means, χ^2 and ϕ for cross-tabulations.
[b]$p < 0.05$.
[c]Impaired < normal and borderline.
[d]Impaired < borderline < normal.

In order to determine the ability of the CAMCI to identify impaired subjects we dichotomized the study sample into those with normal or borderline performance on the traditional neuropsychological test battery ($n = 41$) and those with impaired performance ($n = 18$; see Supplemental E–Table 1). Because the CAMCI standardization sample was older than the average age of our subjects (i.e., minimum 60 years old), we used the raw scores from the various measures to determine the ability of the test to distinguish between the Impaired and Normal/Borderline subjects. Of the various CAMCI measures, the Go/No-Go task, ATM, Backwards Digit Span, Trees, and Word Recall showed significant differences between the Impaired subjects and those with normal or borderline Global Ratings. In terms of the T-scores, the Go/No-Go task, ATM, and Word Recall showed significant differences between the impaired subjects and those with normal or borderline global ratings (see Supplemental E–Table 2). The Picture Recognition measure differed significantly among all three subject groups.

The raw scores from the CAMCI were then entered into a stepwise discriminant function analysis (SPSS v17, SPSS Inc., Chicago, IL) that was able to successfully distinguish between the normal/borderline subjects and the impaired subjects using six test variables (Wilks' $\lambda = 0.42$, $df = 6$, $p < 0.001$): Executive Functions 1 and 2, Backwards Digit Span, ATM, Word Recall, and Visual Recognition from the shopping trip. Of the 41 normal/borderline subjects, 40 were correctly classified (i.e., 1 false-positive error), and 13 of 18 of the impaired subjects were correctly classified (i.e., 5 false-negative errors) for an overall accuracy of 89.8%. A leave-one-out cross-validation was able to correctly classify 83.1% of the subjects.

Using these six tests, the sensitivity of the CAMCI to classify Global Impairment was 0.72, with a specificity of 0.98. The negative predictive value was 0.89 (assuming a prevalence of 30% as measured in this sample), which means that 89% of the participants with negative test result actually performed in the normal/borderline range (i.e., not impaired). The positive predictive value, which is the proportion of people who were

classified as impaired by the CAMCI who actually were impaired (by testing) was 0.93 (assuming a 30% prevalence).

We repeated the discriminant function analysis using the T-scores from the CAMCI and were able to successfully sort the data using three test variables (Wilks' $\lambda = 0.62$, $df = 3$, $p < 0.001$): Word Recall, Picture Recognition, and Reverse Digit Spans. All 41 of the normal/borderline subjects were correctly classified, and 10 of 18 of the impaired subjects were correctly classified (86.4% accuracy). A leave-one-out cross-validation was able to correctly classify 79.7% of the subjects. Using the T-scores, the sensitivity of the CAMCI to classify Global Impairment was 0.56, with a specificity of 1.00. The negative predictive value was 0.84 and the positive predictive value was 1.00 (assuming a 30% prevalence).

At 12 weeks posttesting, 52 of the 59 participants returned for follow-up (88%) assessment, 48 of the participants tested at 12 weeks returned at 24 weeks (92%), and 52 of the original 59 participants returned for 24 week retesting (88%). We measured the stability of the CAMCI raw scores between baseline and 12 weeks, and baseline and 24 weeks among the 43 participants whose Global Impairment ratings changed 1 point or less during the 24 weeks of follow-up. We chose this group because we wanted to ensure that we were measuring stability in a group of individuals who had not had a significant measurable change in overall test performance. Within this group, the median stability after 12 weeks of follow-up was 0.32 and the mean was 0.40; the median after 12 weeks was 0.46 with a mean of 0.42 (Table 3).

Table 3. Stability of CAMCI® T-Scores over 24 Weeks of Follow-Up

	Baseline—12 weeks[a]	*Baseline—24 weeks*[b]
CAMCI® raw scores		
Star	−0.059	[c]
Trees	0.320	*0.287*
Verbal Memory	*0.735*	*0.748*
Executive Functions-1	*0.751*	*0.320*
Executive Functions-2	0.028	−0.068
Forward Span	0.272	*0.483*
Reverse Span	*0.288*	*0.431*
ATM	0.222	0.032
Typing	*0.329*	*0.542*
Verbal Recognition	*0.406*	*0.686*
Item Recall	*0.616*	*0.538*
Incidental Recall	0.320	0.185
Bank	*0.558*	*0.459*
Post Office	*0.663*	*0.614*
CAMCI T-scores		
Attention	−0.059	0.096
Forward Span	*0.286*	*0.481*
Reverse Span	0.260	*0.442*
Go/No-Go 1	*0.860*	0.198
Go/No-Go 2	0.043	−0.061
Driving	*0.447*	*0.709*
ATM	0.172	0.064
Words	*0.343*	0.264
Verbal Recognition	*0.472*	*−0.006*
Picture Recognition	*0.425*	0.033
Item Memory	*0.621*	*0.525*
Incidental Memory	0.269	0.208

[a]For $p < 0.05$, $r > 0.279$.
[b]For $p < 0.05$, $r > 0.273$.
[c]All subjects scored without error at follow-up.

Discussion

The results of this analysis indicate that the CAMCI may prove useful in clinical and research applications as a method for screening for cognitive impairment. The test was easily administered to the study participants and comments from the study subjects suggest that it was well tolerated. The sensitivity of the test relative to the Global Impairment Rating was 0.72; the positive predictive value, which corrects for the apparent prevalence of abnormality, was 0.93. The negative predictive value was excellent (i.e., 89%). Although stability varied as a function of the specific test and the specific time interval, the median correlation coefficient was 0.46 for 24-week retest.

In this study, we use the term stability to refer to test–retest reliability that persists over a longer time period; in our case, 24 weeks. This concept differs from the reliability that is measured over the short term, e.g., less than 2–4 weeks, which is more of a direct measurement of the instrument (i.e., raw scores) and is not affected by any changes in physiological state that may occur over a longer period of time. To put these findings into context, the stability of the Global Impairment rating over the same 24 week interval was 0.75; the median correlation for the Domain ratings was 0.63. Thus, the overall ratings of cognitive function (i.e., the gold standard) are more stable than the screening tests. This is likely due to several factors, among which is the fact that the CAMCI was given three times to the subjects, and the full assessment only twice. The additional practice may have attenuated some of the sensitivity of the CAMCI scores (esp., incidental learning and memory). Second, the rating scores represent the combined information from one or more individual test scores (adjusted for age, education, gender, and race). One bad test score will not have a major effect on the overall rating, and two scores within a single domain may be unstable, but the resulting rating may not change over time, masking any intratest variability.

This study has several limitations: the sample is small, the range of cognitive performance on the larger test battery is relatively limited, and the range of ages and risk factor profiles of the volunteers is restricted. Nevertheless, these data support previous observations of the relative merits of the CAMCI in identifying patients with HIV-associated dementia.[13] It is important to emphasize that in the classification scheme used here,[10] a rating of "borderline" is not an indication of mild impairment—performance is generally within 1–1.5 standard deviation unit of the expected value (i.e., $35 \leq T \leq 45$). "Mild" impairment requires performance more than 1.5 standard deviation units below that expected relative to the demographic norms. Thus, this study asked whether the CAMCI was sensitive to mild impairment, and not to an intermediate range that may be more related to state phenomena rather than consistent alterations of performance.

The major limitation of the study is that the CAMCI standardization sample, which provides the basis for the T-scores, was drawn from a large group of community residing individuals over the age of 60 years. Therefore, we had to use the raw scores for the discriminant function analysis and did not correct for age or education; accuracy was actually superior to when we used the T-scores. Therefore, what is critically needed for the CAMCI to be specifically useful in the infectious

disease clinic or HIV clinical trial are normative data from uninfected, cognitively normal individuals with the major risk factors for HIV infection. With those data, it will be possible to create an automated algorithm within the CAMCI to inform the physician that there is a need for further assessment.

The CAMCI offers the potential for assisting in the typical HIV clinic. The tablet PC is small, portable, and easy to use. The CAMCI may be viewed as being more ecologically valid than traditional "paper and pencil" tests, especially the driving "simulator" (shopping trip) as it mimics the sorts of daily tasks that community-dwelling patients likely encounter. The shopping trip in particular tests abilities not usually assessed in typical clinical test batteries but that are relevant to everyday functioning, including prospective memory (remembering to do something in the future), incidental memory (remembering material that you did not expect to have to remember), and decision making. Because the tasks are not viewed as threatening, and because the subject/patient is responding without an examiner appearing to look over their shoulder, the test is not as anxiety provoking as a "full" neuropsychological assessment. This is critical because a substantial minority of clinic patients may initially refuse formal neuropsychological testing because they find it unpleasant and threatening. However, if a screening test identifies a potential problem, then this may help the referring physician to have the patient agree to a more complete evaluation.

We did not find any significant differences in test performance (either on the CAMCI or the full test battery) as a function of HIV status. This is useful for the purposes of our study as it means that we did not have to attempt to make adjustments for infection status. As noted below, this makes the CAMCI more useful for detection of any defect in cognitive test performance and not just problems related to HIV disease. In other studies,[14] we have found that HIV infection is less important for predicting test performance (at least in this age range) than are other medical factors such as cardiovascular disease. Consequently, our current results are in line with the current state of the literature in terms of cognition in long-term survivors with HIV infection.

It must be emphasized that the goal of this research was not to identify a screening test specific for HIV-related disorders. Rather, the goal is to identify those individuals who appear to be at-risk for some degree of cognitive impairment, and for whom a more detailed neurobehavioral examination is in order. It is only after a complete medical history, neurologic examination, and neuropsychological testing (and perhaps neuroimaging) that a diagnosis can be assigned. What we have shown here is that the CAMCI has the potential to identify those individuals who are likely to be found to have impaired performance on a more detailed test battery.

As effective as HAART is in fighting HIV disease, it likely has no impact on non-HIV–associated diseases of the nervous system—especially those age-related conditions such as Alzheimer's disease or vascular dementia. Indeed, among patients in an HIV clinic who are over the age of 65 years, the likelihood that a developing dementia is HIV-related is actually lower than the likelihood that it is age-related. The prevalence of HIV-associated dementia may be as high as 2% across all ranges, whereas the risk of Alzheimer's disease and related dementias is 5% for all individuals over the age of 65.[15] Having a measure such as the CAMCI available for use by the clinicians could potentially increase the rate of diagnosis of dementia syndromes (see, for example, Lin and colleagues[16]). The data available so far on the CAMCI[13] suggest that with availability of an appropriate normative sample, this screening tool could have great utility in clinical and research settings.

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Author Disclosure Statement

No competing financial interests exist.

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