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Development and Validation of the Memory Orientation Screening Test (MOST ™): A Better Screening Test for Dementia

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Abstract

Objectives: Accurate, economical identification of cognitive impairment would increase dementia detection and improve care of older patients. **Design:** Analysis of archival neuropsychological data combined 3-word recall, time orientation, list memory, and clock drawing into the Memory Orientation Screening Test (MOST ™). The MOST was compared with Folstein Mini Mental State Examination (MMSE) and Mini-Cog to detect dementia presence and severity, and convergence with standardized neuropsychological tests. Internal consistency, retest reliabilities, completion likelihood, and time costs were calculated. **Results:** The MOST was significantly more sensitive than MMSE or Mini-Cog, twice as accurate as MMSE for identifying mild dementia, better correlated with standardized memory tests, more reliable over time, and minimally related to depression. **Conclusions:** The MOST is routinely administered in less than 5 minutes by a medical assistant, more accurately identifies dementia and severity than current screening tests, and emulates longer memory testing, making it valuable for Annual Wellness Visits and many applied clinical settings.

Keywords

Alzheimer's, dementia, screening, test

Introduction

Dementia represents a growing public health problem[1,2] because of increasing incidence in an aging population. Medicine faces the unique challenge to accurately identify dementia in an efficient manner to best use existing treatments to reduce costs to society,[3] and individual symptom burden.

New health care regulations,[4] slated to go into effect in January 2011, require physicians to identify impaired cognition at the annual physical examination of patients over the age of 65. However, dementia is notably underdiagnosed.[5,6] Physicians rarely measure, are unaware of, or fail to document cognitive decline until significant and often irreversible losses have occurred.[7]

Complicating timely identification of dementia is patient denial or anosognosia; limited family reports of functional change[8]; absence of specific physiological markers[9]; and the length, complexity, and insensitivity of current screening tests.[10,11]

A better screening test would increase the probability of earlier diagnosis and improve ability to monitor change over time and treatment response.[12] Such a test would also increase identification of cognitively impaired patients at higher risk of delirium[13] and better address complex care management of demented patients in acute care[14] and rehabilitation[15,16] settings.

To address these needs, we developed a test that is twice as fast as the Mini Mental State Examination (MMSE),[17] 7-Minute Screen,[8] or Montreal Cognitive Assessment (MoCA),[18] and significantly more effective than the MMSE or Mini-Cog,[11] in detecting the presence and severity of dementia. The Memory Orientation Screening Test (MOST) can be administered by briefly trained staff and interpreted quickly and is well accepted by patients.

Methods

Data

A total of 1752 patient records were used in this development and validation process, 1474 neuropsychology (NP) evaluation records and 278 records from a geriatric psychiatry (GP) practice. Test items were identified using 548 cases (NP-1) gathered between 2001 and 2004. A second group of 702 cases (NP-2), gathered from 2005 to 2008, was utilized to validate the resulting instrument. A subset (NP-3) of 224 records of NP-2 patients reevaluated typically at a 6- or 12-month interval (median 7 months) after initial assessment was used in test–retest analysis. A shorter interval (median 48 days)

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Box. Neuropsychological Battery of Cognitive Tests and Domains

- Intelligence
  - Wechsler Adult Intelligence scale—Revised (WAIS-R)
- Language
  - 41-item Boston Naming Test
  - Controlled Oral Word Association Test (COWAT)
- Memory
  - Wechsler Memory Scale—Revised (WMS-R):
    - Logical Memory (stories) I and II
    - Visual Reproduction (designs) I and II
  - Shopping List Test–learning and delayed recall
  - NameIt Test
- Omnibus Measures
  - Folstein Mini Mental State Examination
- Visuospatial functions
  - Gollin Incomplete Pictures
- Attention
  - Trail Making A (time in seconds 0-500)
  - WMS-R Attention and Concentration subtest
  - Integrated Visual and Auditory Continuous Performance Test (IVA-CPT)
  - Executive functions
    - Trail Making B (time in seconds 0-500)
    - Clock drawing
    - Proverb interpretation
- Depression
  - Geriatric Depression scale, short form

test–retest reliability analysis was performed using the MOST scores from the records of 175 GP patients (GP-1) seen from 2008 to 2009. The administration and scoring time for the MOST was recorded on 103 consecutive patients (GP-2).

Demographic data are presented in Table 1. All patients were referred by a physician or agency in the community. The NP patients were evaluated by 1 of 6 licensed psychologists in the NP practice of the primary author. The GP patients were seen in the practice of the second author where the MOST was administered by a medical assistant.

The NP patient scores from selected tests (see Box)[19-27] within a comprehensive neuropsychological test battery were entered into a database. The scores that comprise the MMSE, MOST, and Mini-Cog were all drawn from a single administration of the MMSE (with an additional time orientation item), followed by a single clock drawing and the administration of the Name-It test. As such, there are no order effects to confound the comparison of the MOST, MMSE, and Mini-Cog.

Additionally, each psychologist made a clinical diagnosis, according to *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition [*DSM-IV*]) criteria,[28] and rated dementia severity (DS) on a 0 to 3 Clinical Dementia Rating type[29] scale. Diagnoses and severity ratings were based on age- and education-adjusted neuropsychological test scores, medical and psychiatric history, and interview with a family informant. Psychologists were blinded to the MOST and Mini-Cog scores. The GP patients were diagnosed by the second author based on the *DSM-IV* criteria, guidelines promulgated by various working groups,[30-33] physical and mental status examination, laboratory and imaging results, and family reports. Diagnoses and severity levels are also presented in Table 1.

Component Selection

Clinical experience and preliminary analyses of the NP-1 data identified a set of core test items that reflected memory and executive functions and combined economically into an easily administered test. This analysis yielded 4 principal components:

1. Memory—3-word recall after an intervening task
2. Orientation—year, season, month, date, day of week, and time of day
3. Sequence memory—immediate and unforewarned recall of a 12-item grocery list
4. Time—clock-drawing organization and abstraction scored by a standardized 8-point system.

For the NP-2 and NP-3 groups, the grocery list was replaced by the Name-It Test (naming and immediate recall of 12 pictured household objects) to decrease administration time and accommodate patients with hearing or writing limitations. Each item was assigned a single-point value, resulting in a scoring range of 0 to 29 for the resulting measure, the MOST.

Statistical Methods

The MOST scores were calculated for each patient. The MMSE was scored using traditional methods, counting the first spelling error in WORLD backward, yielding a score of 0 to 30. Mini-Cog scores were calculated by summing 3-word memory (0-3) and a rating of either 2 (intact clock) or 0 (at least 1 clock error) for a total score of 0 to 5.

A randomly selected half of the NP-2 group was used as the test sample to study the effect of cutoff values on sensitivity, specificity, and percentage of correct classification for the MOST, MMSE, and Mini-Cog, using a DS score of ≥ 1 (mild dementia). A MOST cutoff score of 19 correctly classified the highest percentage of cases in the test sample as demented versus not demented, but a score of 18 was selected because it improved specificity with minimal loss of sensitivity. The MMSE cutoff was set at 25. Many studies have used an MMSE cutoff of 23/24; our choice substantially increased the correct classification of cases in our sample when using that test. A cutoff of 2 was chosen for the Mini-Cog based on established literature.

The other half of NP-2 group was used as the cross-validation sample to estimate sensitivity and specificity and to compare the abilities of MOST, the MMSE, and the Mini-Cog to identify dementia by comparing the area under the receiver operating characteristic (ROC). A chi-square test was used to compare the areas under the ROC curve.

The MOST, MMSE, and Mini-Cog scores for the total NP-2 group were correlated with DS and with standardized neuropsychological tests of delayed memory and executive functions

Table 1. Demographics, Diagnoses and Dementia Severity Levels for Each Group

Variable	NP-1 (n = 548)	NP-2 (n = 702)	NP-3 (n = 224)	GP-1 (n = 175)	GP-2 (n = 103)
Demographics					
Age, year	77.6 ± 7.7	78.2 ± 7.2	78.5 ± 6.8	79.6 ± 7.1	78.1 ± 9.0
Education, year		12.8 ± 3.1	13.2 ± 3.2	12.9 ± 3.0	12.5 ± 4.2
Female gender	64%	61%	61%	71%	68%
Diagnosis	N (percent)	N (percent)	N (percent)	N (percent)	N (percent)
Normal cognition	52 (9.4)	56 (8.0)	6 (2.7)	9 (5.1)	7 (6.8)
Mild cognitive impairment	106 (19.3)	130 (18.5)	22 (9.8)	34 (19.4)	19 (18.4)
Dementia of all types	390 (71.2)	516 (73.5)	196 (87.5)	132 (75.4)	77 (74.8)
Alzheimer's disease		402 (57.3)	152 (67.9)	93 (53.2)	42 (40.8)
Frontotemporal dementia		71 (10.1)	32 (14.2)	13 (7.4)	8 (7.7)
Vascular dementia		24 (3.4)	5 (2.2)	20 (11.4)	15 (14.6)
Mixed or other dementia		19 (2.7)	7 (3.1)	6 (3.4)	12 (11.7)
Dementia severity		N (percent)	N (percent)	N (percent)	N (percent)
Normal (0)	52 (9.4)	56 (8.0)	6 (2.7)	9 (5.1)	7 (6.8)
MCI (0.5)	106 (19.3)	130 (18.5)	22 (9.8)	34 (19.4)	19 (18.4)
Dementia of all types	390 (71.2)	516 (73.5)	196 (87.5)	132 (75.4)	77 (74.8)
Mild dementia (1.0)		177 (25.2)	59 (26.3)	36 (20.6)	20 (16.5)
Mild-to-moderate dementia (1.5)		144 (20.5)	62 (27.7)	27 (15.4)	17 (12.6)
Moderate dementia (2.0)		93 (13.3)	40 (17.9)	26 (14.9)	15 (14.6)
Moderate-to-severe dementia (2.5)		62 (8.8)	22 (9.8)	20 (11.4)	11 (10.7)
Severe dementia (3.0)		40 (5.7)	13 (5.8)	23 (13.1)	14 (13.6)

Abbreviations: NP, neuropsychology; MCI, mild cognitive impairment.

and the 15-item GDS. Pearson correlations and their levels of significance versus 0 were computed using SAS/STAT Software Version 9.1.3 of the SAS System for Windows (SAS Institute Inc, Cary, North Carolina). Tests of significant differences between correlations used Fisher z transformation and tested the normalized difference versus 0.

To measure the internal consistency of the MOST, Cronbach α was calculated using Stata Version 9 (StataCorp, College Station, Texas). Test–retest correlations over a typically 6- or 12-month interval were calculated for the MOST, MMSE, Mini-Cog, DS rating, and neuropsychological tests of memory and executive function using the NP-3 group. A test–retest correlation analysis was performed on GP-1 MOST scores at a short-term interval. Administration and scoring time for the MOST was calculated on 103 consecutive patients from the GP-2 group. The percentage of patients who successfully completed the MOST was determined using the combined GP groups.

Results

Overview of Test Scores

Statistical characteristics for the 3 screening tests and the major neuropsychological measures are presented in Table 2.

Internal Consistency

Cronbach α for MOST score with the 4 components of memory, orientation, sequence, and time is 0.79. Component deleted αs range from 0.71 to 0.76, indicating that all 4 components contribute to the overall score and that the overall measure has a moderately high level of internal consistency.

Inter-Rater Reliability

Inter-rater reliability was not examined directly in this study. The memory, orientation, and sequencing components require few scoring decisions. A pilot study using 324 freehand drawn clocks from a separate database found very high agreement (Pearson $r = .90$) among pairs of 6 briefly trained raters using our 8-point scoring system. Because predrawn outlines reduce face size variability and the time component contributes less than one third of the total MOST score, we view $r = .90$ as the minimum inter-rater reliability.

Test–Retest Reliability

The MOST demonstrated very high test–retest reliability over a brief interval (mean = 66 days, SD = 61.4) with a Pearson $r = .91$ ($P < .001$). The difference in the MOST scores between administrations was less than 3 points regardless of direction (mean = 1.95, SD = 1.8, 95% CI, 1.6-2.3) with no appreciable practice effect.

In NP-3, the MOST, MMSE, Mini-Cog, and neuropsychological tests demonstrated high test–retest reliability ($r = .62$-$.77$) over a longer interval (mean = 9.2 months, SD = 4.4 months). All test–retest correlations were significant ($P < .001$), although the Mini-Cog was less reliable than the MOST ($P = .014$). Because dementia progressed over this interval (mean decline = 0.2 DS units), a subsequent analysis of the 128 cases of stable dementia (no change in severity) was conducted. This analysis found the MOST to have significantly higher test–retest reliability than either the MMSE ($P = .03$) or the Mini-Cog ($P = .04$). For all cases, the difference in MOST scores between administrations was 3 points or less, regardless of direction

Table 2. Test Scores for Neuropsychology Groups

Variable	NP-2 (n = 702)	NP-3 (n = 224)
Screening tests		
MOST, mean (SD)	14.9 (5.7)	13.9 (5.0)
MMSE, mean (SD)	23.7 (5.1)	23.5 (4.4)
Mini-Cog, mean (SD)	2.4 (1.7)	2.3 (1.7)
Neuropsychological tests		
Wechsler Memory scale−Revised		
Logical Memory II raw, mean (SD)	6.7 (8.0)	4.4 (6.6)
Logical Memory II scaled, mean (SD)	77.7 (22.2)	70.7 (21.3)
Visual Reproduction II raw, mean (SD)	7.5 (9.6)	4.4 (7.2)
Visual Reproduction II scaled, mean (SD)	75.4 (24.6)	67.2 (21.0)
Shopping List Test Delayed Recall, mean (SD)	4.9 (3.4)	4.0 (3.1)
Trail Making part B (secs) mean (SD)	298.8 (166.9)	287 (158.4)
COWAT (F, A, S total), mean (SD)	32.7 (14.1)	33.2 (14.4)
Wechsler Adult Intelligence scale−Revised (Sim, Comp, P-A, Scale Score), mean (SD)	8.9 (2.6)	9.22 (2.4)

Abbreviation: MOST, memory orientation screening test; MMSE, Mini Mental State Examination; SD, standard deviation.

(mean = 2.60, SD = 2.23, 95% CI, 2.4-3.0) with no appreciable practice effect.

Validity

Results in Table 3 demonstrate high convergent validity for the MOST, MMSE, and Mini-Cog (Pearson $r = .70$-$.82$), correlating significantly ($P < .001$) with each other and with Dementia Severity (DS). The MOST had significantly higher correlation with DS than either the MMSE ($P < .01$) or the Mini-Cog ($P < .001$). The MMSE had significantly higher correlation with DS than the Mini-Cog ($P = .02$).

In the validation group, each of the 3 screening tests showed adequate ability to discriminate demented from nondemented patients, with the MOST surpassing the accuracy of the MMSE and Mini-Cog. The ROC analyses performed on the validation group yielded 0.90 area under the curve ([AUC] 95% CI, 0.87-0.94) for the MOST, with sensitivity of 0.85 and specificity of 0.76, correctly classifying 83% of the patients. The MMSE had 0.86 AUC (95% CI, 0.82-0.90), with sensitivity of 0.70 and specificity of 0.80, correctly classifying 73%. The Mini-Cog had 0.84 AUC (95% CI, 0.80-0.89), with 0.67 sensitivity, 0.87 specificity, and 72% correct classification rate. The AUC of the MOST is significantly higher than that of the MMSE (χ^2 [1 df] = 5.03, $P = .02$) and the Mini-Cog (χ^2 [1 df] = 12.11, $P < .001$), but the MMSE and Mini-Cog did not differ from each other (χ^2 [1 df] = 0.63, $P = .4$). The ROC graphs are presented in Figure 1.

Table 3 also shows that each of the 3 screening tests had significant relationships ($P < .001$) with standardized neuropsychological measures. The MOST had significantly higher correlations with the 3 memory tests than did the MMSE or Mini-Cog. Variable differences were seen among the screening tests in comparison to Trail Making B, the COWAT, and the WAIS-R subscale scores.

The MOST, MMSE, and Mini-Cog correlated significantly ($P < .001$) and positively with education and inversely with age. Dementia severity, predictably, had the opposite relationship with these variables. The MOST, MMSE, Mini-Cog, and DS demonstrated low correlations with depression, although the MOST and DS correlations reached statistical significance ($P < .05$) because of large sample size.

Utility

Utility of a screening test includes the factors of speed, ease of use, applicability to clinical situations, and acceptance by patients, particularly elderly with impaired cognition. Of the 278 GP patients (mean MOST score = 13.8, mild-to-moderate dementia), 255 (92%) completed the MOST, including 17 with severely impaired scores (0-4). Reasons for noncompletion included confusion (12), vision impairment (5), insufficient English fluency (3), and refusal (3). Time of administration and scoring averaged 4.5 minutes (mean = 273 seconds, SD = 58 seconds). Completion time was shorter for patients with higher MOST scores ($r = -.29$, $P < .01$), reflecting milder levels of dementia. Completion time was not significantly correlated ($r = .17$, $P = .08$) with age.

Comment

The convergence of an aging population, potential disease-modifying treatments for dementia, and the societal benefit of delaying nursing home placement increases the importance of easier and earlier detection of cognitive impairment in the elderly population at a minimal cost of time, resources, and dollars. Our goal was to develop a test that could be administered in less than 5 minutes by a variety of clinical staff, be reliably and easily scored without the need of a complex algorithm or a computer program, and be readily accepted by patients. Such a test should differentiate those patients who require further evaluation or prompt initiation of medication and supportive services from those who can be monitored over successive visits for signs of decline, or can be reassured that their cognition is normal.

All 3 tests that we considered possessed good ability to screen for dementia. This study demonstrates the MOST to be significantly more accurate in determining the presence or absence of dementia than either the MMSE or Mini-Cog and to more precisely measure a patient's DS. This greater accuracy coupled with the stability of MOST scores over brief (1-3 months) and longer (6-12 months) time periods and a reliable confidence interval of change provides a quantifiable basis that could potentially be used in a variety of clinical settings.

Table 3. Comparison of MOST, MMSE, and Mini-Cog With Outcome Measures

	Correlations of MOST, MMSE, Mini-Cog to Other Cognitive Tests						Pairwise Comparison of Correlations of MOST, MMSE, Mini-Cog to Other Cognitive Tests (Absolute Values)					
	MOST		MMSE		Mini-Cog		MOST vs MMSE		MOST vs Mini-Cog		MMSE vs Mini-Cog	
TEST Statistic	Pearson *r* (*P* Value)						*Z* ratio (*P* Value)					
MMSE	.81	<.001										
Mini-Cog	.82	<.001	.70	<.001								
Dementia severity	−.80	<.001	−.74	<.001	−.68	<.001	3.06	.002	5.39	<.001	2.35	.02
LM-II scale score	.65	<.001	.57	<.001	.55	<.001	2.49	.01	2.91	.003	0.42	.68
VR-II scale score	.64	<.001	.54	<.001	.55	<.001	2.67	.007	2.50	.01	0.17	.87
SLT-R raw	.73	<.001	.63	<.001	.62	<.001	3.61	<.001	3.90	<.001	0.29	.77
Trail making B	.67	<.001	.61	<.001	0.60	<.001	1.70	.09	2.15	.03	0.46	.65
COWAT	.46	<.001	.48	<.001	0.36	<.001	0.53	.60	2.29	.02	2.84	.004
WAIS Sim, Comp, P-A	.61	<.001	.65	<.001	0.57	<.001	1.22	.23	1.22	.23	2.48	.01

Abbreviations: MOST, memory orientation screening test; LM-II, Logical Memory; VR-II, Visual Reproduction; SLT-R, Shopping List Test Delayed Recall−Revised; WAIS, Wechsler Adult Intelligence scale.

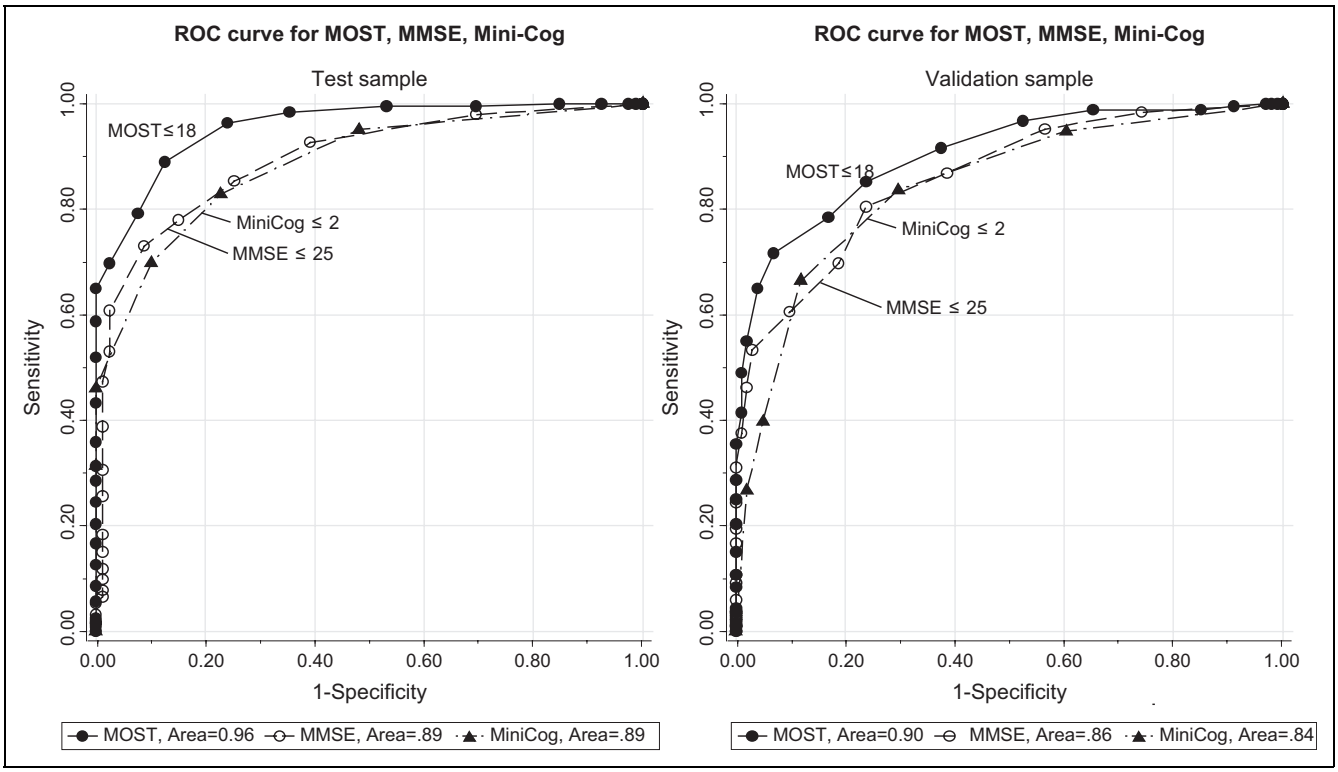

Figure 1. Receiver Operating Characteristic (ROC) Curves for test and validation groups.

A brief measure such as the MOST could be used by a medical or nursing assistant to gather quantitative diagnostic information before the primary care provider sees the patient, allowing for a more effective use of professional time, which is advantageous when caring for medically complex elderly individuals.[34]

Total time for MOST administration and scoring averages under 5 minutes (4.5 ± 1), similar to the administration time for the Mini-Cog (3.2 ± 2)[35] and notably less than that of the MMSE (approximately 10 minutes[36,37]) or the 7-Minute Screen or MoCA.[35] We believe that such brevity would increase the likelihood of cognitive assessment occurring routinely and, paired with the increased ability to target patients with mild dementia, improve the clinician's ability to intervene at an earlier opportunity.

This study has several limitations. It should be replicated in other centers. Additionally, although our use of data drawn from tertiary memory programs reflects a greater heterogeneity

of diagnoses and disease severity than is represented in many studies, it underrepresents the cognitively normal elderly population. A recently completed investigation[38] extends the normative data for independent elders with presumably normal cognition. This investigation also samples a more racially diverse population as we recognize the overrepresentation of Caucasians (>95%) which is an artifact of referral patterns to our practices rather than a selection bias of the authors. A Spanish version of the MOST is under development for subsequent validation and deployment. We anticipate easy portability into other languages because the MOST components are common and universal.

The MOST may be useful for following patients in a variety of settings, including presurgical surveillance in high-risk elderly populations such as those undergoing elective orthopedic surgery where cognitive impairment has been shown to increase the risk of postoperative delirium, and in applications within rehabilitation and home health settings, where length of stay, falls risk,[39,40] and ability to assume independent self-care may be compromised by cognitive problems.

Most importantly, incorporating the MOST within an annual wellness visit will provide an objective measure of cognition that will meet health care goals to include "detection of any cognitive impairment"[41] alongside other routine measurements (height, weight, and BMI) to develop a better personalized prevention plan.

Declaration of Conflicting Interests

The author(s) declared no conflicts of interest with respect to the authorship and/or publication of this article.

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