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Telephone Interview for Cognitive Status: Creating a crosswalk with the Mini-Mental State Examination

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The Telephone Interview for Cognitive Status: Creating a crosswalk with the Mini-Mental State Exam

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Abstract

Background—Brief cognitive screening measures are valuable tools for both research and clinical applications. The most widely used instrument, the Mini-Mental State Examination (MMSE) is limited in that it must be administered face-to-face, cannot be used in participants with visual or motor impairments, and is protected by copyright. Alternative screening instruments, such as the Telephone Interview for Cognitive Status (TICS) have been developed and may provide a valid alternative with comparable cut point scores to rate global cognitive function.

Methods—MMSE, TICS-30, and TICS-40 scores from 746 community dwelling elders who participated in the Aging, Demographics, and Memory Study (ADAMS) were analyzed with equipercentile equating, a statistical process of determining comparable scores based on percentile equivalents on different forms of an examination.

Results—Scores from the MMSE and the TICS-30 and TICS-40 corresponded well and clinically relevant cut point scores were determined; for example, an MMSE score of 23 is equivalent to 17 and 20 on the TICS-30 and TICS-40, respectively.

Conclusions—These findings provide scores that can be used to link TICS and MMSE scores directly. Clinically relevant and important MMSE cut points and the respective ADAMS TICS-30 and TICS-40 cut point scores have been included to identify the degree of cognitive impairment

among respondents with any type of cognitive disorder. These results will help with the widespread application of the TICS in both research and clinical practice.

Keywords

Telephone Inventory for Cognitive Status (TICS); Mini-mental State Exam (MMSE); cognitive screening measures; dementia instruments

1. Introduction

Brief cognitive screening instruments are often used to detect cognitive impairment and dementia in longitudinal and population based epidemiological studies. The most widely used instrument to assess global cognitive impairment is the Mini-Mental State Examination (MMSE) [1]. However, given that face-to-face screening for large epidemiological studies can be both time-consuming and costly, telephone-screening instruments have been developed as an alternative approach. These instruments have demonstrated strong correlation with face-to-face assessments and may be preferable due to their ease of use and widespread applicability [2–4].

The Telephone Interview for Cognitive Status (TICS) [5] is a global mental status test that can either be administered over the telephone or face-to face. The TICS demonstrates a high correlation with the MMSE and has been found to have excellent sensitivity (94%) and specificity (100%) in differentiating participants with Alzheimer's disease (AD) from normals [5]. A major advantage to using the TICS is that unlike the MMSE, this screening tool can be administered to individuals with severe visual and/or motor impairments[6]. Cognitive domains measured by the TICS include orientation, concentration, short-term memory, language, praxis, and mathematical skills. Since its inception, the TICS has been modified into several different versions and translated into several languages.

A modified version of the TICS, the TICS-M [7, 8], includes delayed recall, verbal comprehension, and also requires that the respondents provide the first and last name of the US President and Vice President instead of providing their own address, which was included in the original version. The TICS-M has been found to have excellent sensitivity (>99%) and specificity (86%) in the screening and detection of AD [9, 10]. In fact, with the addition of the delayed recall item of the TICS-M, the sensitivity of the measure for detecting cognitive impairment has been enhanced, and the ceiling effects have been reduced relative to the MMSE[11, 12]

While several studies have reported a high correlation between the TICS and MMSE, to our knowledge no previous study has used equipercentile equating to directly link scores and cut points on these two measures. A possible explanation is that several different permutations of the TICS have been evaluated in previous studies [13, 14]. In addition, since the difficulty of the instruments may vary somewhat, a purely proportional scoring approach to convert scores on the instruments may not be appropriate. Using data from the Aging, Demographics, and Memory Study (ADAMS) the goal of the current study was to develop a metric that allows the linkage of scores on permutations of the TICS and TICS-M to the MMSE. In doing this, cut points that denote cognitive impairment and dementia on the MMSE can then be readily applied to scores obtained on the TICS.

2. Methods

2.1 Study Design

This design is a cross-sectional analysis of baseline data from a longitudinal study.

2.2 Study participants

The study included 746 community dwelling elders who were participants in The Aging, Demographics, and Memory Study (ADAMS). The ADAMS is a supplement to the Health and Retirement Study (HRS) funded by the National Institutes of Aging (NIA) with the specific aim of conducting a population based study of dementia. The rationale, design, recruitment, and site characteristics of the ADAMS study are described in detail elsewhere[15].

Briefly, a random subsample of 1,770 individuals aged ≥70 was selected for participation in the ADAMS study. From this initial sample, 227 participants died before an initial assessment could be completed and 687 participants refused an assessment or did not participate for various other reasons[15]. Therefore, initial ADAMS assessments were completed for 856 participants between August 2001 and December 2003. Of these 856 participants who underwent a cognitive assessment, 42 were not assessed with the MMSE, and another 68 were missing variables necessary to calculate ADAMS TICS-30 and/or TICS-40 scores, yielding a final sample of 746 older adults available for the current study.

2.3 Participant Evaluations

All participants received an ADAMS in-person evaluation, which was a 3–4 hour structured assessment conducted in the participant's residence by a nurse and a neuropsychology technician. The full details of the assessment and diagnostic procedures are described elsewhere[15] and are also available online at http://hrsonline.isr.umich.edu/adams/overview/summary_2.htm. In brief, the following information about the participant was collected from a knowledgeable informant: demographics, chronological history of cognitive symptoms, medical history, current neuropsychiatric symptoms, and Clinical Dementia Rating (CDR) scale[16] evaluating the severity of cognitive and functional impairment. During the assessment, the participant completed a battery of neuropsychological measures, administered in standard fashion, including the MMSE. The HRS self-respondent questionnaire (including the modified TICS) was also obtained. The values for the TICS-30 and TICS-40 used in the current study (Table 2) were scored using components from the neuropsychological battery. There was no overlap between the MMSE items (administered in full) and the TICS items derived from the neuropsychological test battery [15]. In addition, dementia diagnoses were established by a consensus expert panel of neuropsychologists, neurologists, geropsychiatrists, and internists who reviewed all information collected during the in-home assessment and who assigned the final diagnoses. The consensus panel reviewed each case and assigned a diagnosis in 2 stages, first without and then with medical records. The consensus panel used clinical judgment to assign the final diagnosis. Diagnosis fell within 3 broad categories, 1) Normal Cognitive Function; 2) Cognitive Impairment Not Demented (CIND); and 3) Dementia. Dementia diagnosis was based on guidelines from the Diagnostic and Statistical Manual of Mental Disorders-TR, Fourth Edition, Text Revision [17], and in addition, diagnoses of Alzheimer disease, Lewy body disease, and vascular dementia were based on currently accepted criteria[18–20]. CIND was defined as functional impairment reported by the participant or informant, or performance on neuropsychological testing ≥1.5 SD below published norms on any test within a single cognitive domain such as orientation, memory, language, executive function or praxis.

2.4 Study Variables

Mini-Mental State Examination (MMSE)—The MMSE[1] was completed as part of the structured ADAMS assessment. The MMSE takes approximately 5 to 10 minutes to administer, and has a maximum score of 30 points. The MMSE total combines scores from five cognitive domains, including orientation (10 points), memory (3 points for registration and 3 points for recall), attention/calculation (5 points), language (8 points), and visuospatial abilities (1 point).

The MMSE serves as an indicator of general mental status, and is used to screen for cognitive impairment, to detect cognitive changes that occur over time, and to assess the effects of therapeutic agents on cognitive functioning[1, 21–23].

ADAMS Telephone Interview for Cognitive Status-30 (TICS-30)—While several different versions of the TICS, including the TICS and the TICS-M have been utilized and evaluated in previous studies[7, 14, 24–26], the ADAMS study used an abbreviated version of the TICS that was previously used by Breitner et al[7] in a clinical study of dementia[27]. The ADAMS TICS-30 is comprised of 8 items that results in a maximum score of 30 points, and includes the following variables and corresponding point values: date (5 points), address (3 points), counting backward (2 points), word list learning (10 points), subtractions (5 points), responsive naming (2 points), repetition (1 point), and President/Vice President's last name (2 points). (Table 1)

ADAMS Telephone Interview for Cognitive Status-40 (TICS-40)—The ADAMS TICS-40 is comprised of 9 items that result in a maximum score of 40 and is similar to the TICS-M, which incorporates the use of a word list delayed recall measure, and which has been used in previous studies[8, 15, 24]. The TICS-40 includes the following variables and corresponding point values: date (5 points), address (3 points), counting backward (2 points), word list learning (10 points), subtractions (5 points), responsive naming (2 points), repetition (1 point), and President/Vice President's last name (2 points), and delayed word list recall (10 points). All items that comprise the TICS-40 are the same as those used in the TICS-30, with the single modification of adding the word list delayed recall task (Table 1).

2.5 Statistical Analysis

For this study, direct comparisons of scores were performed using an equipercentile equating method. By this method, scores from two different measures, such as the ADAMS TICS-30 and MMSE, may be considered equivalent to one another if their corresponding percentile ranks in any given group are equal. A comprehensive explanation of equipercentile equating is described elsewhere[28]. Briefly, equipercentile equating has the desirable property that the equated scores will always be within the range of possible scores under the traditional conceptualization of percentiles and percentile ranks. Out-of-range scores, which often occur with mean and linear equating, do not occur with equipercentile equating. However, equipercentile equating leads to irregular score distributions when actual values are graphed. Thus, we used a log linear smoothing method[29] to smooth the raw scores of MMSE and TICS and create a regular distribution. Respondent-level sampling weights derived from the national population sample used in ADAMS were used in our study to facilitate accurate calculation and interpretation of statistical estimates. All analyses were conducted using SAS Version 9.1 (SAS Institute, Cary, NC).

3. Results

The demographic makeup of this study population has been described elsewhere [15] and summarized in Table 2. A range of cognitive functioning, including normal, CIND, and dementia was present across this population-based study of older persons. In terms of clinical dementia diagnoses, the majority of the current sample was diagnosed as normal/non-dementia (306; 41%), with 81 (11%) and 77 (10%) participants being diagnosed as having possible and probable Alzheimer's disease, respectively. For cognitive impairment due to vascular disease, 89 (12%) were mild/ambiguous, 17 (2%) were possible, 19 (3%) were probable, and 20 (3%) were definite cognitive impairment due to vascular disease. A stroke was diagnosed in 32 (4%) of participants. The remaining 105 participants had cognitive impairment due to other dementing conditions, such as "subcortical dementia", frontal lobe dementia, diffuse Lewy

body disease, etc. When the study population is considered by Clinical Dementia Rating Scale (CDR)[16], 226 (30%) scored 0 (no dementia); 346 (46%) scored 0.5 (mild cognitive impairment); 98 (13%) scored 1 (mild dementia); 48 (6%) scored 2 (moderate dementia); and 24 (3%) scored 3 (severe dementia). The remaining 4 participants did not have CDR scores available.

In both the ADAMS TICS-30 and TICS-40, lower scores indicate more severe cognitive impairment. Among the 746 participants in the current study, mean score on the TICS-30 was 17 (SD = 6; median = 18; range = 0–29) and mean score on the TICS-40 was 21 (SD = 9; median = 22; range = 0–39). In the 30-point scoring system of the MMSE, lower scores indicate more severe cognitive impairment. Among the 746 participants, mean score on the MMSE was 23 (SD = 6; median = 24; range = 3–30). The MMSE and TICS are highly correlated; the intra-class correlation coefficient for the MMSE vs. TICS-30 was 0.80 with 95% confidence limits (0.78, 0.83), and the intra-class correlation coefficient for the MMSE vs. TICS-40 was also 0.80 with 95% confidence limits (0.78, 0.83). Table 3 illustrates clinically important cut points for weighted smoothed data on the MMSE and corresponding cut points on the ADAMS TICS-30 and TICS-40, with the cumulative distribution of participants being included as well. For example, a cut point score of 23 on the MMSE is equivalent to cut point scores of 17 and 20 on the TICS-30 and TICS-40 respectively. For each of the cut point categories for the MMSE, a correlation was calculated with the corresponding cut points for the TICS-30 and TICS-40. This yielded weighted kappa values of 0.69 for both, indicating substantial agreement exceeding chance. The calculated correct classification for the TICS-30 was 87.6 %, and for the TICS-40 was 88.1%.

The plot of equipercentile equivalent scores on the ADAMS TICS-30 and the MMSE is presented in Figure 1. An example is presented in this figure where a score of 18 on the TICS-30 is equivalent to a score of 24 on the MMSE and falls at the 22nd cumulative percentile (Figure 1). A nomogram that demonstrates scores on the MMSE and their respective equivalents on the ADAMS TICS-30 and TICS–40 is presented in Figure 2. For example, at the higher end of the scales a score of 30 on the MMSE links with scores of 25 – 30 on the TICS-30, and scores of 32 – 40 on the TICS-40. Similarly, on the low end of the scales, a score of 10 on the MMSE links with scores of 5 on either the TICS-30 or TICS-40.

4. Discussion

The current study used equipercentile equating to develop a crosswalk between scores on the MMSE and those on the ADAMS TICS-30 and TICS-40. While the MMSE [1] is the most widely used clinical screening instrument for detecting the presence and severity of cognitive impairment, and can be used for monitoring cognitive changes over time, it does have a number of important limitations. First, it relies heavily on verbal responses and requires reading and writing ability, thus, educational biases are inherent [30]. Second, there are marked ceiling effects in young, intact individuals, or in highly educated older individuals. Floor effects can be seen with participants with moderate to severe stage dementia. The internal consistency ranges widely, from an alpha of 0.54 to 0.96. Finally, its sensitivity is poor for detecting mild cognitive impairment [31, 32]. In contrast, the TICS does not rely on visual ability or literacy, and in one study controlling for age, education and hearing impairment, TICS-M was a strong predictor of dementia, MCI and cognitive impairment [9]. The addition of the delayed recall questions on the TICS, may drive the increased sensitivity of this test for differentiating MCI from dementia [33].

This study was not intended to evaluate the validity of the TICS-30 and TI.CS-40 as a screening instrument, but our findings provide further evidence that the TICS instrument is a useful alternative to the MMSE. Several previous studies have also described the high correlation

between the MMSE and TICS[5, 9, 14, 34]. However, this study is unique in that it provides equivalent scores between the widely accepted cut points for cognitive impairment on the MMSE and two different versions of the TICS. The use of the ADAMS dataset, which is a large nationally representative sample represents an additional strength of the current study.

This study has several important clinical applications. Given the increasing rate of occurrence of dementia, quick, reliable, and valid screening instruments are essential. Furthermore, since the TICS can be administered both in person and over the phone, it can be used with those who have significant visual or motor impairments, unlike the MMSE.

The current study has important limitations that should be noted. While variables that are included in the ADAMS TICS-30 and TICS-40 are similar to the original versions of the TICS[5] and TICS-M[8] (Table 2), not all of the cognitive items included in the TICS and TICS-M were included in the ADAMS dataset. Thus, the crosswalk we describe here is applicable only in comparison between the MMSE and either the TICS-30 or TICS-40. Another important limitation is that the TICS scores were calculated from components of other neuropsychological tests used in the ADAMS, and were not obtained by telephone. Also, the TICS scores used in this study were based on face-to-face responses done with different ordering than in the standard TICS administration. Although it could be assumed that participants would provide similar responses, the findings from this study were not replicated with telephone administration in the standard order. Lastly, the TICS scores here were based on face-to-face responses done with different ordering than in the standard TICS administration. Although it could be assumed that participants would give similar answers, the findings from this study were not replicated with telephone administration in the standard order.

Despite these limitations, this is the first study to create a crosswalk between TICS and MMSE scores using equipercentile equating. The TICS has some major advantages over the MMSE including its ability to be administered either by telephone or face-to-face and is potentially more cost-effective relative to the MMSE. The MMSE is widely used in both clinical and research settings to measure cognitive impairment and screen for dementia, and thus, the MMSE cut points are widely recognized and accepted. Our study provides cut points for the TICS that mirror these commonly accepted cut points on the MMSE, with which clinicians and researchers alike are familiar and comfortable.

Acknowledgments

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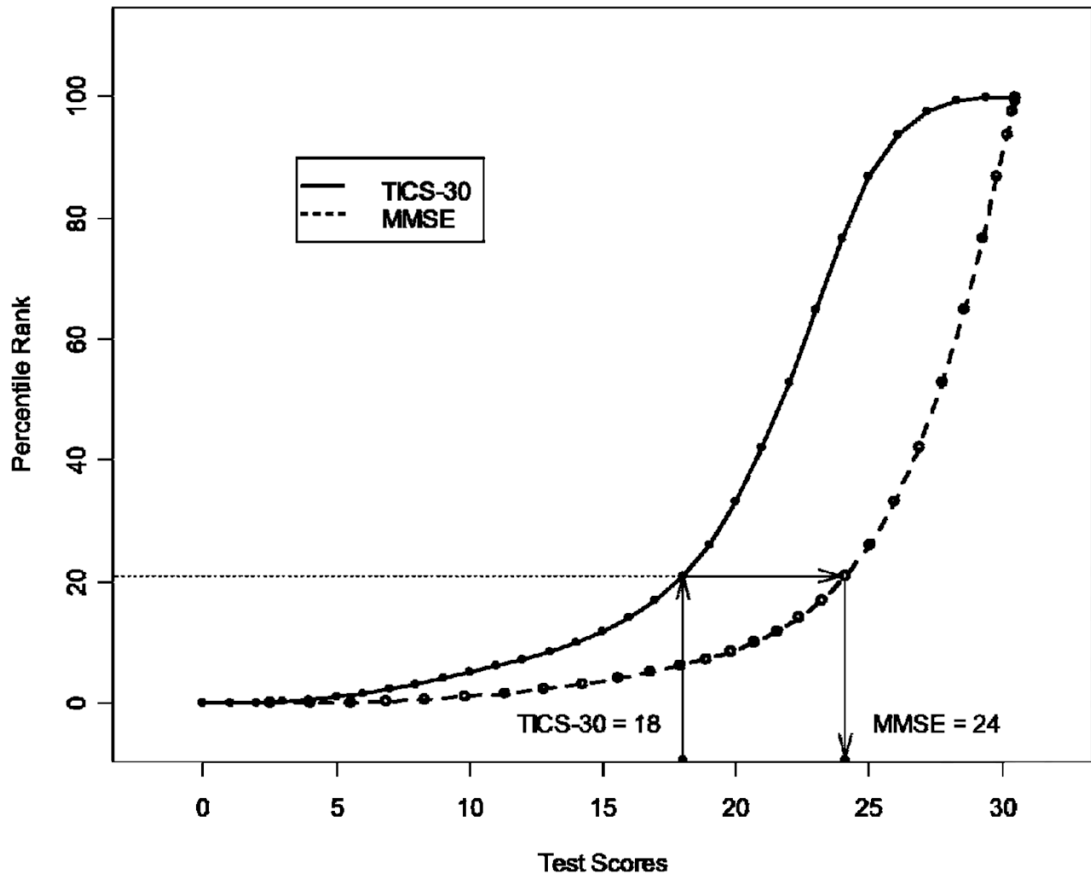
Figure 1. Corresponding Scores and Percentile Ranks for TICS-30 and MMSE Scores
Figure 1 illustrates the cumulative percentile ranks (y-axis) and corresponding scores on the TICS-30 and MMSE (x-axis). For example, the figure illustrates that a score of 18 on the TICS-30 is equivalent to a score of 24 on the MMSE, and that the cumulative percentile of participants in the current sample who earned these scores on both measures is 23%.
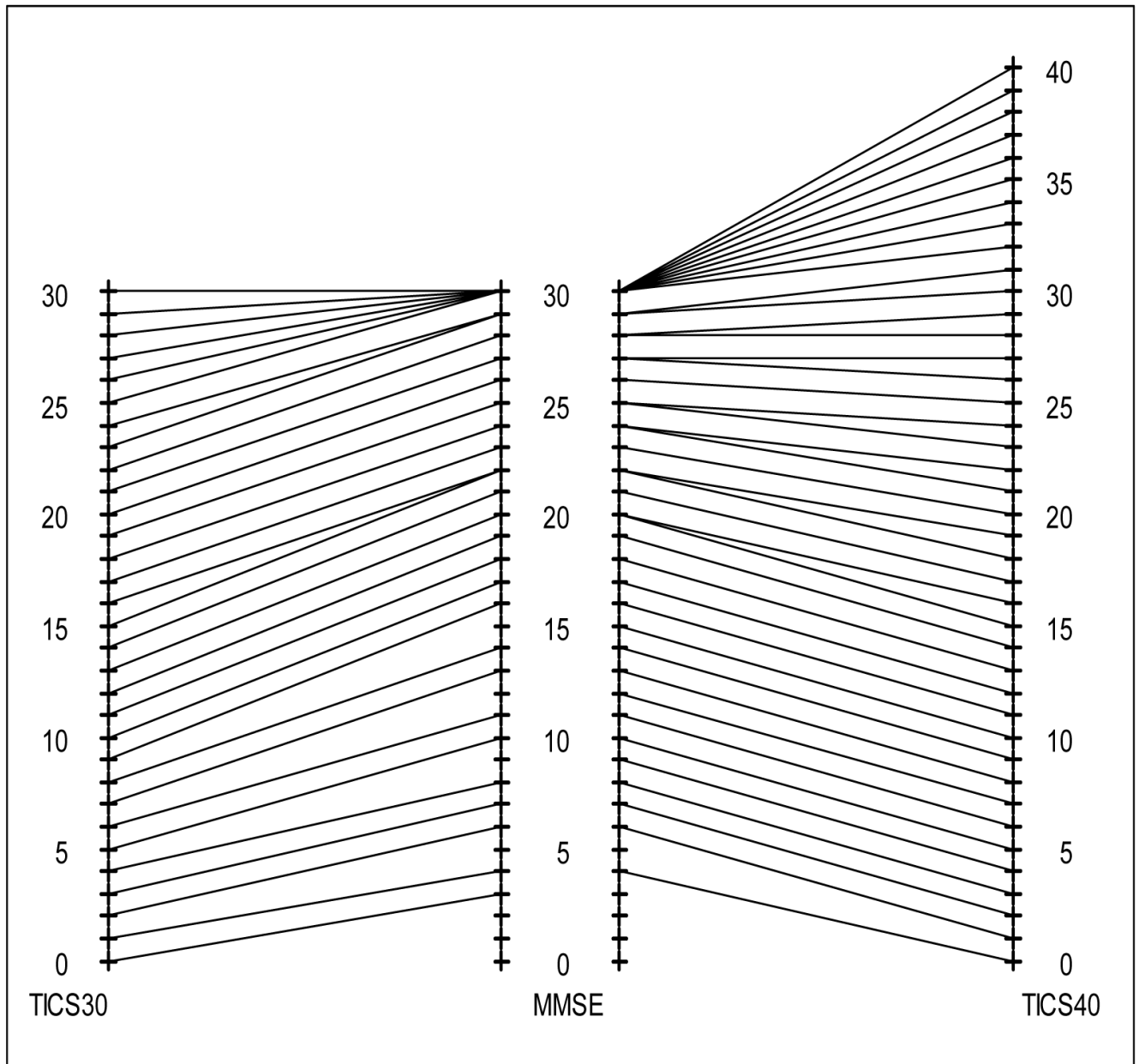
Figure 2. Crosswalk of Corresponding Scores of the TICS-30 and TICS-40 with the MMSE
Figure 2 illustrates a nomogram of the conversion crosswalk for scores on the TICS-30 and
TICS-40 to those on the MMSE. The nomogram was derived with equipercentile equating
methods using scores on the TICS-30, TICS-40, and MMSE from participants in the ADAMS
dataset. The middle of the nomogram shows the range of scores from 0–30 on the MMSE. The
left side of the nomogram shows the range of scores on the TICS-30 (0–30) that correspond
with the respective MMSE scores, and likewise, the right side of the nomogram shows the
range in scores on the TICS-40 (0–40) that correspond with the respective MMSE score. For
example, the lines that radiate from a score of 30 on the MMSE, correspond with scores of 25–
30 on the TICS-30 and scores of 32–40 on the TICS-40. As another example, the lines that
radiate from a score of 10 on the MMSE, correspond with a score of 5 on the TICS-30 and

with a score of 5 on the TICS-40. This table can be used to convert any score on either the TICS-30 and/or TICS-40 to a score on the MMSE, and vice-versa.

Table 1

Adaptations of the Telephone Interview for Cognitive Status Instrument

TICS (41 Pts)	TICS-M (50 Pts)	TICS-30 (30 Pts)	TICS-40 (40 Pts)
1. State full name (2)	State full name (2)	N/A	N/A
2. Date (5)	Date (5)	Date (5)	Date (5)
3. Address (5)	Age/Phone Number(2)	Address (3)	Address (3)
4. Counting Backward (2)	Counting Backward (2)	Counting Backward (2)	Counting Backward (2)
5. Word List Learning (10)	Word List Learning (10)	Word List Learning (10)	Word List Learning (10)
6. Subtractions (5)	Subtractions (5)	Subtractions (5)	Subtractions (5)
7. Responsive Naming (4)	Responsive Naming (4)	Responsive Naming (2)	Responsive Naming (2)
8. Repetition (2)	Repetition (2)	Repetition (1)	Repetition (1)
9. Pres/Vice Pres (2) (Last Name Only)	Pres/Vice Pres (4) (First and Last Name)	Pres/Vice Pres (2) (Last Name Only)	Pres/Vice Pres (2) (Last Name Only)
10. Finger Tapping (2)	Finger Tapping (2)	N/A	N/A
11. Word Opposites (2)	Word Opposites (2)	N/A	N/A
12. N/A	Delayed Word Recall (10)	N/A	Delayed Word Recall (10)

-TICS is based on the original Brandt et al. 1998 version; TICS-M is based on the modified version by Welsh et al., 1993; and the ADAMS TICS-30 and -40 are based on the version used in the ADAMS study as described in Langa et al., 2005.

-Item 12, delayed word recall, was included only in the 40-point version of the TICS used in the current study.

Pts = Designated amount of points that each item is worth in calculating total score; N/A = Not Assessed.

Table 2

Participant Demographics

Characteristic	Study Sample, N=746
Age	81.0 ± 6.8 (70.0–102.0)
Men	320 (42.8%)
White	540 (78.3%)
Education (years)	10.3 ± 4.3 (0.0 –17.0)
Married	306 (41.0%)
Geographical Location	
Northeast	103 (13.8%)
Midwest	149 (20.0%)
South Atlantic	201 (26.9%)
South Central	142 (19.0%)
West	151 (20.2%)
Living in Nursing Home	45 (6.0%)
MMSE	23 ± 6 (3–30)
TICS-30	17 ± 6 (0–29)
TICS-40	21 ± 9 (0–39)

All data are presented as mean ± standard deviation and (range) or number (percentage) of participants.

^
 Marital status was missing for one participant

Table 3

Cut points and cumulative distribution of MMSE scores and corresponding ADAMS TICS-30 and TICS-40 scores for weighted smoothed data

	MMSE (N=746)		TICS-30 (N=746)		TICS-40 (N=746)	
Score		Cumulative Percent (%)	Score	Cumulative Percent (%)	Score	Cumulative Percent (%)
≤ 30 [*] No Cognitive Impairment		100	≤ 30	100	≤ 40	100
≤ 23 [*] Mild Cognitive Impairment		18	≤ 17	19	≤ 20	17
≤ 17 [*] Moderate Cognitive Impairment		6	≤ 10	6	≤ 12	6

Abbreviations: MMSE = Mini-Mental State Examination; ADAMS = Aging, Demographics, and Memory Study (ADAMS) assessment conducted nationwide in the participant's residence; TICS = Telephone Interview for Cognitive Status

[*]
Cognitive classification per Tombaugh, 1992