

# Diagnostic Accuracy of the Swedish Version of the Rowland Universal Dementia Assessment Scale (RUDAS-S) for Multicultural Cognitive Screening in Swedish Memory Clinics

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## Abstract.

**Background:** The number of people with a migration background and dementia is increasing in Europe. All patients with suspected dementia have the right to an appropriate cognitive assessment and correct diagnosis for optimal treatment and support. Rowland Universal Dementia Assessment Scale (RUDAS) cognitive screening instrument is less affected by language, culture, and educational background, and adapted for use in multicultural populations.

**Objective:** To compare the diagnostic accuracy of RUDAS-S to the Swedish version of Mini-Mental State Examination (MMSE-SR) for detecting dementia in a multicultural group of outpatients in Swedish memory clinics.

**Methods:** We tested 123 outpatients (36 nonnative Swedish), in 4 memory clinics in Southern Sweden with RUDAS-S to supplement the usual cognitive assessment.

**Results:** RUDAS-S had moderate to good diagnostic performance for detecting dementia in a multicultural population in Sweden, with an area under the receiver operating characteristic curve (AUC) of 0.81. At a cutoff score <25 its sensitivity was 0.92, specificity 0.60, and accuracy 76%. The AUC for the MMSE-SR was 0.79. At a cutoff score <23 its sensitivity was 0.65, specificity 0.81, and accuracy 73%.

**Conclusion:** RUDAS-S is at least as accurate as MMSE-SR for detecting dementia in memory clinics in Sweden and can be used for all patients undergoing a cognitive assessment, irrespective of their cultural, language, and educational background. However, there is a need for other cross-cultural cognitive tests to complement RUDAS-S to extend cognitive examination.

**Keywords:** Assessment, cognition, cross-cultural screening test, dementia, ethnic minority, immigrant, Mini-Mental State Examination, Rowland Universal Dementia Assessment Scale

## INTRODUCTION

Worldwide, every third second, there is a new case of dementia. More than 131 million people are expected to live with dementia in 2050 [1]. An increase in the number of older immigrants in

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Europe is also expected, which means an expected increased number of people with dementia in this group [2–4]. In 2021, 20% of Sweden's population was registered with another country of birth and most of this group are from countries outside of Europe [5]. The top 15 countries were Syria, Iraq, Finland, Poland, Iran, Somalia, Afghanistan, former Yugoslavia, Bosnia and Herzegovina, Turkey, Germany, Eritrea, India, Thailand, and Norway [5]. Thus, the need for valid methods for the assessment of cognitive function in people with diverse backgrounds is becoming increasingly important [6].

### *Challenges*

Dementia is a clinical diagnosis, and the assessment includes physical, neurological, and psychiatric examinations, laboratory tests of blood and cerebrospinal fluid, brain imaging, cognitive tests, and interviews of relatives [7]. There are challenges for early and reliable diagnosis in people with a migration background. These challenges may be due to, for example, language barriers, cultural differences, and the use of conventional cognitive tests [4, 8]. Most neuropsychological tests used during the cognitive assessment are developed in western populations. These tests are influenced by culture, language, (quality of) education, and literacy [9–12].

The most widely used cognitive screening instrument in Europe, the Mini-Mental State Examination (MMSE) [13], was developed in USA and is widely used in the European context [14]. MMSE is reliable and valid for testing cognition [13], but test results are influenced by age and education [15], language, and cultural background [16] and is therefore less suitable for use in multicultural populations.

Today, several neuropsychological tests have been studied in culturally, educationally, and linguistically diverse populations in Europe, for example the Rowland Universal Dementia Assessment Scale (RUDAS) [17], the European Cross-Cultural Neuropsychological Test Battery (CNTB) [18, 19], and the Multicultural Cognitive Examination (MCE) [20]. However, there is still a lack of cross-culturally validated cognitive screening tests in Europe [6].

### *Possibilities*

RUDAS [21], developed in Australia, is an efficient test with strong dementia psychometric properties, which was specifically developed for use with people from diverse linguistic and cultural backgrounds

[22]. The test is considered to have good accuracy for detecting dementia in various socioeconomic and educational settings, even for those without any formal education [16, 22]. The test can be used in different languages without any adjustment or changes in the test [16, 21]. Since 2017, RUDAS has been recommended in Sweden for cognitive assessment of patients with a mother tongue other than Swedish, or shorter schooling [7]. The RUDAS test results are less affected by language, culture, and education than several other conventional cognitive screening instruments used to detect dementia [16]. The RUDAS is validated in populations from several high-, low-, and middle-income countries, with various languages, cultures, and educational backgrounds [16, 23, 24].

### *Aim*

Patients with a migration background are at risk of misdiagnosis [3, 25–27]. Underdiagnosis, overdiagnosis, or misdiagnosis of dementia can lead to consequences for the patient and their relatives. Development and availability of cross-cultural cognitive screening instruments as well as awareness and knowledge in cross-cultural assessment are desirable and necessary [6].

The aim of the present study was to compare the Swedish version of RUDAS (RUDAS-S) and MMSE-SR test scores and their diagnostics accuracy in nonnative Swedish (NNS), and native Swedish (NS) patients, in Swedish memory clinics.

## **MATERIALS AND METHODS**

### *Study participants and procedure*

Clinical data and test results were collected from outpatients in 4 hospital-based memory clinics, Hässleholm, Malmö, Ystad, and Ängelholm in Southern Sweden. All patients referred to the memory clinics during the period 2018–2019 to assess their cognitive impairment were invited to participate in the study through an informative letter that was sent to them with the invitation to the planned clinical visit. Referrals were mainly from primary care but also in some cases from psychiatric and other specialist clinics. Participating clinics started at different timepoints depending on what their clinic allowed and had agreed on recruiting about 30 patients each. No exclusion criteria for participation were formulated for the study so that everyone who could and

Table 1  
Country of birth, World Bank Group's country classification, years in Sweden and use of interpreter in the study

	Country of birth	World Bank Group's country classification	Years in Sweden	Interpreter
1	Belarus	Upper middle income	25	Yes
2	Bosnia	Upper middle income	22	No
3	Bosnia	Upper middle income	24	No
4	Bosnia	Upper middle income	25	Yes
5	Bosnia	Upper middle income	23	Yes
6	Brazil	Upper middle income	10	No
7	Cameroon	Lower middle income	1	Yes
8	Chile	High income	35	No
9	Chile	High income	42	Yes
10	Colombia	Upper middle income	26	Yes
11	Denmark	High income	53	No
12	Denmark	High income	33	No
13	Denmark	High income	–	No
14	Eritrea	Low income	35	Yes
15	Finland	High income	–	No
16	Former Yugoslavia	Upper middle income	22	Yes
17	Former Yugoslavia	Upper middle income	55	No
18	Iran	Lower middle income	33	Yes
19	Iran	Lower middle income	34	Yes
20	Iran	Lower middle income	30	Yes
21	Iraq	Upper middle income	8	Yes
22	Iraq	Upper middle income	–	Yes
23	Kosovo	Upper middle income	25	Yes
24	Kosovo	Upper middle income	19	Yes
25	Kosovo	Upper middle income	27	Yes
26	Lebanon	Upper middle income	14	Yes
27	Macedonia	Upper middle income	47	Yes
28	Norway	High income	–	No
29	Palestine	Lower middle income	30	Yes
30	Poland	High income	29	No
31	Poland	High income	30	No
32	Poland	High income	23	Yes
33	Poland	High income	50	Yes
34	Taiwan	Upper middle income	52	Yes
35	Thailand	Upper middle income	18	Yes
36	Thailand	Upper middle income	–	Yes

wanted to join, had the opportunity to participate in the study. Translated study information and consent forms were available to patients who had not mastered reading in Swedish. The translations were made by translation agencies. Oral and written study information was given to the patients at the visit. The patients were included in the study after written consent.

Formal interpreters were available to all NNS patients on a need's basis. All interpreters came from the procured interpreting agency. The majority of NNS patients in the study were assessed with an interpreter but 12 patients were not, due to their ability to speak Swedish or preferring help from a relative. Of these 12 patients, 4 originated from another Nordic country, 5 from a non-Nordic European country, one from an Asian country, and 2 from a South American country (Table 1).

The clinical diagnoses in the four participating memory clinics were based on physical, neurologi-

cal, and psychiatric examinations, laboratory tests of blood, brain imaging, cognitive tests, and interviews with relatives according to the national guidelines and recommendations [7]. The cognitive tests included MMSE and Clock drawing test. Cube copying, cerebrospinal fluid was performed in some but not all patients. In the clinics, the diagnoses were made in a joint diagnosis round where several physicians and other healthcare personnel from the clinics participated.

In the present study, the Swedish version of the MMSE (MMSE-SR) and the Swedish version of the RUDAS (RUDAS-S) were used to assess cognitive impairment. The MMSE, which was used as a reference when assessing the diagnostic accuracy for dementia, gives a total score between 0 and 30 points, and includes orientation, attention and calculation, memory and memory recall, language, and figure copying [13]. The RUDAS gives a total score between

0 and 30 points, and includes memory and memory recall, visuospatial orientation (body orientation), praxis, visuospacial drawing, judgment, and language [21].

The Functional Assessment Questionnaire (FAQ) [28] was used to assess instrumental activities of daily living (IADL), with a range of 0 to 30 points. A score of  $\geq 9$  points, or dependence in 3 or more activities, was used to indicate impaired IADL. The 20-item Swedish version of the Geriatric Depression Scale (GDS-20) was used to screen for depression using the cutoff  $\geq 6$  points for suspected depression [29].

All clinical diagnoses (including MCI) were classified according to the International Classification of Diseases (ICD-10) diagnostic system [30], or specifically expressed in the medical records (e.g., dementia with Lewy bodies) in all the participating multidisciplinary specialist memory clinics.

All care staff at the memory clinics were trained in the administration of the RUDAS-S and interpreter-mediated cognitive assessment by the research group (authors 1 and 2) before the study. The nurses performed all cognitive tests. Tests that were part of the regular investigation were prioritized and performed before the RUDAS-S. Diagnoses were ultimately decided by the responsible physician. MMSE was included in the regular routine examination and was therefore known to the physician, who could also see the RUDAS-S results, but they were not used to interpret them.

### Ethics

The present study was approved by the local ethics committee of Lund University (approval Nos. 2016/292 and 2018/109). Documented informed consent was obtained with a signature from all participating patients.

### Statistical methods

Demographic and clinical characteristics of patients diagnosed with dementia and other patients were compared using descriptive statistics. To compare group means of continuous variables, a Student *t* test was used for normally distributed variables and a Mann–Whitney U test for nonnormally distributed variables and variables with uneven scaling properties.

To test the significance of differences in the distribution of categorical variables, a Fisher exact test

or Pearson  $\chi^2$  was used. Spearman correlations were used for correlation analyses (age, years of education, MMSE-SR, RUDAS-S, and FAQ). Binary logistic regression analyses for RUDAS-S and MMSE-SR were conducted to investigate the probability of dementia adjusted by age and years of education. Missing data in years of education were substituted by the use of multiple imputations (specifically, 5 consecutive imputations).

To compare the diagnostic accuracy of the RUDAS-S and MMSE-SR for dementia, receiver operating characteristic (ROC) curve analyses were used using the clinical diagnosis of dementia as the criterion standard. No other covariates were used. An area under the ROC curve (AUC) between 0.9 and 1.0 is considered excellent, and 0.8 to 0.9 Good, 0.7 to 0.8 fair, 0.6 to 0.7 poor, and 0.5 to 0.6 failed [31].

The Clinical Calculator 1 from the Vassar Stats website ([www.vassarstats.net/clin1.html](http://www.vassarstats.net/clin1.html)) was used to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio (LR)+ and LR– with 95% confidence interval (CI) at different cutoff points. All other analyses were performed with IBM SPSS Statistics for Windows (version 27; IBM Corp., Armonk, NY, USA).  $p < 0.05$  was considered significant.

## RESULTS

### Participants

A total of 180 patients received information letters and were invited to participate in the study from the respective clinics. In all, 127 patients were included in the study (Fig. 1). Of these, one did not complete the assessment program, one did not receive a diagnosis until almost 2 years after the assessment, and 2 did not complete both cognitive tests, leaving a final sample of 123 patients for the ROC analyses. Thirty-six (28%) were NNS: 5 originated from another Nordic country, 7 from a Middle Eastern country, 3 from an Asian country, 15 from a non-Nordic European country, 4 from a South American country, and 2 from an African country. The number of years living in Sweden varied between 1–55 years, with a mean of 32 and a median of 27 years ( $n = 31$ ) (Table 1).

The NNS group was classified by the origin country level socioeconomic position according to the

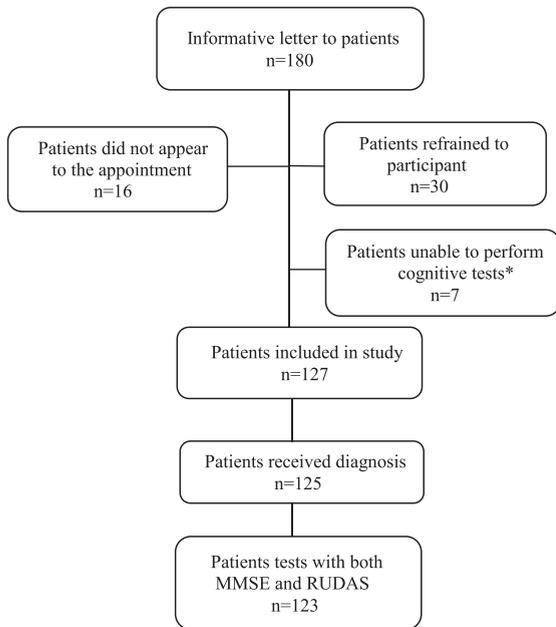


Fig. 1. Flowchart of the participants. \*Due to severe cognitive impairment or too advanced disease.

World Bank Group's country classification. Eleven were classified as high, 19 as upper middle, 5 as lower middle, and 1 as low-income level (Table 1).

### Diagnoses

Totally 63 patients were diagnosed with dementia: 15 patients with Alzheimer's disease, 21 with mixed Alzheimer's and vascular dementia, 10 with vascular dementia, 2 with Lewy body dementia, 2 with Parkinson's dementia, and 5 with frontotemporal dementia. Also 8 patients were diagnosed with nonspecific dementia, including one patient with normal-pressure hydrocephalus.

A dementia diagnosis was not given to 62 patients: 13 patients were diagnosed with subjective cognitive impairment (SCI), 35 with mild cognitive impairment (MCI), 3 were diagnosed with depression, 1 with posttraumatic stress disorder (PTSD), 6 with burnout syndrome, 1 with fibromyalgia, and 3 with a neurological disorder: 1 with dysphasia and 2 with parkinsonism.

### Demographics/subject characteristics

There were no statistical differences in age comparing NNS and NS patients, or sex (Table 2). NNS patients had significantly fewer years of educa-

tion ( $9.2 \pm 4.1$ , range, 1–17 versus  $11.2 \pm 3.6$ , range, 6–20,  $U = 884.5$ ,  $p = 0.025$ ).

Mean MMSE-SR score was significantly lower in the NNS patients than in the NS patients, but mean RUDAS-S score did not differ between the NNS patients and the NS patients. Scores of FAQ ( $14.1 \pm 8.0$  versus  $11.6 \pm 8.0$ ,  $U = 747.5$ ,  $p = 0.197$ ) and GDS ( $6.0 \pm 4.7$  versus  $5.2 \pm 4.1$ ,  $U = 815.5$ ,  $p = 0.454$ ) did not differ between the NNS and NS groups (Table 2). The prevalence of dementia diagnoses did not differ between NNS and NS patients ( $\chi^2 = 1.27$ ,  $p = 0.32$ ). The characteristics of the patients with and without a clinical dementia diagnosis are presented in Table 3.

FAQ data were available for 94% of the NNS patients and 83% of the NS patients. As expected, significantly higher FAQ scores were found in the group with dementia ( $U = 753$ ,  $p < 0.001$ ). The prevalence of depression ( $GDS-20 \geq 6$  points) was higher in the group with other diagnoses than in those with dementia (46% versus 18%; Fisher's exact test,  $p = 0.004$ ). When we excluded patients with depression, burnout, and PTSD ( $n = 9$ ) from the analysis, the difference remained significant (40% versus 18%; Fisher's exact test,  $p = 0.018$ ).

Scores for the RUDAS-S and the MMSE-SR were significantly lower in the group with dementia than the group with other diagnoses (Table 3).

### Correlation

There was a significant correlation between the RUDAS-S and MMSE-SR scores ( $r_s = 0.59$ ,  $p < 0.001$ ) when combining the 2 groups. There was also a significant correlation between the RUDAS-S score and age ( $r_s = -0.45$ ,  $p < 0.001$ ), between the MMSE-SR score and age ( $r_s = -0.28$ ,  $p = 0.001$ ), RUDAS-S score and years of education ( $r_s = 0.22$ ,  $p = 0.023$ ), MMSE-SR score and years of education ( $r_s = 0.46$ ,  $p < 0.001$ ), and between age and years of education ( $r_s = -0.32$ ,  $p = 0.001$ ). A significant correlation was also identified between MMSE-SR and FAQ scores ( $r_s = -0.48$ ,  $p \leq 0.001$ ), and for RUDAS-S and FAQ scores ( $r_s = -0.41$ ,  $p \leq 0.001$ ).

### Logistic regression

Logistic regression analyses for RUDAS-S and MMSE-SR are presented in Tables 4 and 5. In these regression models, the probability of a dementia diagnosis was, beside the RUDAS-S and MMSE-SR, only significantly affected by age.

Table 2  
Demographic and clinical characteristics of the patient sample

Characteristic	NNS <i>n</i> = 36	NS <i>n</i> = 91	<i>p</i>
Age, y (Mean ± SD)	70.5 ± 12.9	70.8 ± 12.0	0.91 <sup>a</sup>
Female (%)	63.9%	50.5%	0.24 <sup>b</sup>
Years of education, <i>n</i> = 108			
Mean ± SD	9.2 ± 4.1	11.2 ± 3.6	0.025 <sup>c</sup>
Min–max	1–17	6–20	
Dementia diagnosis (%)	21(58.3%)	42(47.2%)	0.32 <sup>b</sup>
RUDAS-S, <i>n</i> = 123			
Mean ± SD	22.6 ± 4.7	22.6 ± 4.6	0.854 <sup>c</sup>
Min–max	15–30	12–30	
MMSE-SR, <i>n</i> = 125			
Mean ± SD	19.1 ± 5.5	24.6 ± 5.2	<0.001 <sup>c</sup>
Min–max	4–29	10–30	

*n*, number; NNS, nonnative Swedish; NS, native Swedish; RUDAS-S, Swedish version of the Rowland Universal Dementia Assessment Scale; MMSE-SR, Swedish version of the Mini-Mental State Examination. <sup>a</sup> Student *t* test; <sup>b</sup> Chi-square test; <sup>c</sup> Mann–Whitney *U*.

Table 3  
Demographic and clinical characteristics of the patient with dementia or other diagnoses

Characteristic	Dementia <i>n</i> = 63	Other diagnoses* <i>n</i> = 62	<i>p</i>
Age, y (Mean ± SD)	77.0 ± 6.6	64.4 ± 13.2	<0.001 <sup>a</sup>
Female (%)	57%	50%	0.43 <sup>b</sup>
Years of education, <i>n</i> = 108			
Mean ± SD	10.0 ± 3.8	11.4 ± 3.8	0.05 <sup>a</sup>
Min–max	1–20	1–20	
NNS patients (%)	58%	42%	0.26 <sup>b</sup>
NS patients (%)	47%	53%	
RUDAS-S, <i>n</i> = 123			
Mean ± SD	20.2 ± 3.9	25.0 ± 3.9	<0.001 <sup>c</sup>
Min–max	12–28	15–30	
MMSE-SR, <i>n</i> = 125			
Mean ± SD	19.9 ± 6.1	25.9 ± 4.0	<0.001 <sup>c</sup>
Min–max	4–30	16–30	
FAQ, <i>n</i> = 114			
Mean ± SD	16.2 ± 7.4	9.1 ± 7.1	<0.001 <sup>c</sup>
Min–max	0–29	0–28	
GDS, <i>n</i> = 110			
Mean ± SD	4.4 ± 3.4	5.9 ± 4.5	0.090 <sup>c</sup>
Min–max	0–17	0–17	

*n*, number; NNS, nonnative Swedish; NS, native Swedish; RUDAS-S, Swedish version of the Rowland Universal Dementia Assessment Scale; MMSE-SR, Swedish version of the Mini-Mental State Examination; FAQ, Functional Assessment Questionnaire; GDS, Geriatric Depression Scale. <sup>a</sup> Student *t* test; <sup>b</sup> Chi-square test; <sup>c</sup> Mann–Whitney *U*. \*SCI, MCI, posttraumatic stress disorder, burnout syndrome, fibromyalgia, and dysphasia, CVI with parkinsonism.

Table 4  
Logistic regression analysis for the diagnosis of dementia; RUDAS-S (*n* = 123)

Variable	PE	SE	<i>p</i>	OR (95% CI)
RUDAS-S	–0.23	0.063	<0.001	0.79 (0.70–0.90)
Age	0.10	0.029	<0.001	1.11 (1.05–1.17)
Years of education	–0.02	0.062	0.79	0.98 (0.87–1.11)

RUDAS-S, Swedish version of Rowland Universal Dementia Assessment Scale; PE, parameter estimate; SE, standard error; OR, odds ratio; CI, confidence interval.

Table 5  
Logistic regression analysis for the diagnosis of dementia; MMSE-SR ( $n = 125$ )

Variable	PE	SE	$p$	OR (95% CI)
MMSE-SR	-0.24	0.055	<0.001	0.79 (0.71–0.88)
Age	0.13	0.030	<0.001	1.14 (1.07–1.20)
Years of education	0.072	0.067	0.28	1.07(0.94–1.23)

MMSE-SR, Swedish version of Mini-Mental State Examination; PE, parameter estimate; SE, standard error; OR, odds ratio; CI, confidence interval.

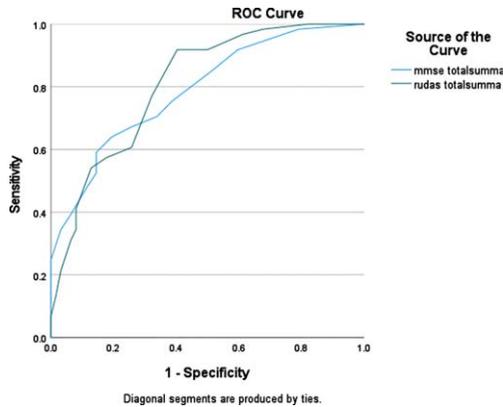


Fig. 2. ROC curve for the RUDAS-S and the MMSE-SR ( $n = 123$ ) for detecting dementia.

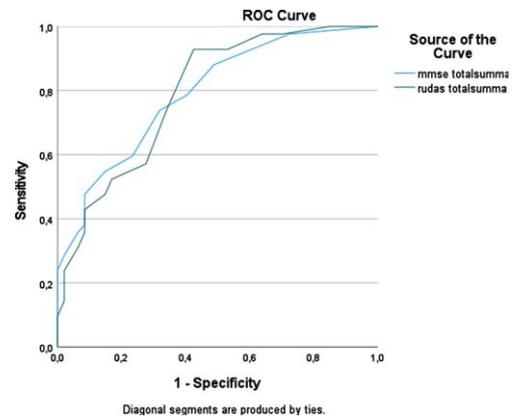


Fig. 4. ROC curve for the RUDAS-S and the MMSE-SR for detecting dementia in the NS groups ( $n = 89$ ).

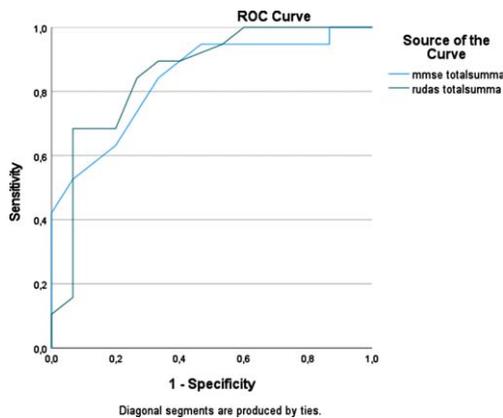


Fig. 3. ROC curve for the RUDAS-S and the MMSE-SR for detecting dementia in the NNS groups ( $n = 34$ ).

To compare the accuracy of diagnostic tests for dementia, ROC curve analyses were used (Fig. 2). The AUC for the RUDAS-S was 0.81 (95% CI 0.73–0.88) and for the MMSE-SR 0.79 (95% CI 0.71–0.87), which indicates that both tests could discriminate with good accuracy between groups of dementia patients and other patients. ROC curve analyses were also used for the NNS and NS groups

separately. In the NNS group the AUC for RUDAS-S was 0.86 (95% CI 0.72–0.99) and for the MMSE-SR was 0.84 (95% CI 0.71–0.97) (Fig. 3). In the NS group the AUC for RUDAS-S was 0.79 (95% CI 0.70–0.88) and for the MMSE-SR was 0.79 (95% CI 0.70–0.88) (Fig. 4). AUC for age alone predicting dementia was 0.79 (95% CI 0.71–0.87).

At the optimal cutoff (<25) with the highest accuracy, RUDAS-S correctly classified 76% of the patients. At the optimal cutoff (<23), the MMSE-SR correctly classified 73% of the patients. At these cutoff scores, sensitivity and NPV were higher for the RUDAS-S. In Tables 6 and 7, the diagnostic accuracy of the RUDAS-S and MMSE-SR is presented at different cutoff scores.

In analyses excluding patients with MCI from the “other diagnoses group,” the AUC increased to 0.93 for RUDAS-S and to 0.84 for the MMSE-SR. At the optimal cutoff scores, sensitivity and specificity increased to 0.92 and 0.85, LR+ to 6.57, LR– to 0.15 for the RUDAS-S. For MMSE-SR sensitivity decreased to 0.60 and specificity increased to 0.88, with LR+ 6.00 and LR– 0.20.

Table 6  
Diagnostic accuracy of the RUDAS-S at different cutoff scores ( $n = 123$ )

Cutoff score	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)	A* %
<22/30	0.57 (0.44–0.70)	0.82 (0.70–0.90)	0.76 (0.61–0.87)	0.66 (0.54–0.76)	3.18 (1.85–5.46)	0.51 (0.37–0.71)	70
<23/30	0.61 (0.47–0.73)	0.74 (0.61–0.84)	0.70 (0.55–0.81)	0.66 (0.53–0.76)	2.31 (1.48–3.61)	0.52 (0.37–0.73)	67
<24/30	0.77 (0.64–0.86)	0.68 (0.55–0.79)	0.70 (0.58–0.80)	0.75 (0.61–0.85)	2.35 (1.58–3.50)	0.33 (0.21–0.53)	72
<25/30 <sup>†</sup>	0.92 (0.81–0.97)	0.60 (0.46–0.72)	0.69 (0.58–0.79)	0.88 (0.74–0.96)	2.24 (1.57–3.20)	0.14 (0.06–0.31)	76
<26/30	0.90 (0.79–0.96)	0.50 (0.37–0.63)	0.64 (0.53–0.74)	0.84 (0.67–0.93)	1.77 (1.28–2.45)	0.19 (0.09–0.41)	70

CI, confidence interval; PPV, positive predictive values; NPV, negative predictive values; LR+, positive likelihood ratio = Sensitivity/(1-Specificity); LR-, negative likelihood ratio = (1- Sensitivity)/Specificity. \*Accuracy (LR+ and LR-weighted for prevalence), <sup>†</sup>optimal cutoff value.

Table 7  
Diagnostic accuracy of the MMSE-SR at different cutoff scores ( $n = 125$ )

Cutoff score	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)	A* %
<22/30	0.60 (0.47–0.72)	0.85 (0.74–0.93)	0.81 (0.66–0.90)	0.68 (0.56–0.78)	4.22 (2.31–7.72)	0.87 (0.34–0.66)	73
<23/30 <sup>†</sup>	0.65 (0.52–0.76)	0.81 (0.68–0.89)	0.77 (0.63–0.87)	0.69 (0.57–0.79)	3.42 (2.03–5.74)	0.44 (0.31–0.63)	73
<24/30	0.68 (0.55–0.79)	0.74 (0.61–0.84)	0.73 (0.60–0.83)	0.70 (0.57–0.80)	2.69 (1.72–4.20)	0.43 (0.30–0.64)	71
<25/30	0.71 (0.58–0.82)	0.66 (0.53–0.77)	0.68 (0.55–0.79)	0.69 (0.56–0.80)	2.14 (1.45–3.16)	0.44 (0.29–0.65)	69
<26/30	0.76 (0.64–0.86)	0.61 (0.48–0.73)	0.67 (0.54–0.77)	0.72 (0.57–0.83)	2.00 (1.39–2.88)	0.39 (0.25–0.61)	69

CI, Confidence Interval; PPV, positive predictive values; NPV, negative predictive values; LR+, positive likelihood ratio = Sensitivity/(1-Specificity); LR-, negative likelihood ratio = (1- Sensitivity)/Specificity. \*Accuracy (LR+ and LR-weighted for prevalence), <sup>†</sup>optimal cutoff value.

## DISCUSSION

In this study, we examined the diagnostic accuracy of RUDAS-S, in a group of outpatients with cultural, educational, and linguistic diversity in memory clinics in the south of Sweden. The result indicates that RUDAS-S had moderate to good diagnostic performance for detecting dementia in our multicultural population.

Worldwide, the MMSE is the most used screening instrument for dementia. Therefore, most RUDAS validation studies compare RUDAS with the MMSE [16]. As found in previous studies [32–36], we confirmed a high correlation between the RUDAS-S and MMSE-SR scores ( $r = 0.59$ ). However, NNS patients had lower MMSE-SR scores than NS patients regardless of diagnosis. This finding is consistent with a Swedish registry-based study, which found NNS patients with dementia had lower MMSE-SR scores than NS patients [37] and confirms earlier studies

showing that the MMSE is influenced by factors such as language, culture, and educational background [9, 16, 38]. By contrast, RUDAS-S scores did not differ between NNS and NS patients, neither in the dementia group nor in the group with other diagnoses. An illustrating case from our study was an NNS patient with 8 years of education, who had an MMSE-SR score of 4 and a RUDAS-S score of 20.

Of 125 included patients who received a diagnosis, two had not performed RUDAS-S. The calculations in group comparisons were not affected by this.

To compare the diagnostic properties of the RUDAS-S and MMSE-SR, ROC curve analyses were performed. AUC was considered good for both the RUDAS-S (0.81) and MMSE-SR (0.79). These results are comparable with results from a recent systematic review and meta-analysis that found a pooled AUC for the RUDAS of 0.89 [16].

Other RUDAS validating studies in high-income countries in mono- or multicultural clinical sam-

ples have shown a higher AUC for RUDAS; 0.92 [36], 0.93 [17], and 0.90 [39]. However, validation studies in low- and middle-income countries report somewhat similar AUC values as found in our study; Thailand's AUC for RUDAS was 0.81 [34], Lebanon's AUC for RUDAS 0.84 [40], and Brazil's AUC for RUDAS 0.87 [41]. Nielsen et al. [17] explain the lower AUC for these studies to be associated with the lower levels of education, which does not apply in our study because the mean years of education for patients with dementia was  $10.0 \pm 3.8$  years.

The lower AUC in the present study is most likely associated with the different traditions for diagnosing dementia across countries and memory clinics. For example, using a descriptive cognitive diagnosis without grading of the cognitive deficit at the first visit with the physician. Dementia diagnoses are often determined after longer follow-up. Furthermore, the diagnoses were due to longstanding tradition based on MMSE-SR rather than RUDAS-S results. Other validation studies of cognitive instruments compared their test results between dementia and healthy control groups. The comparison group in the present study comprised individuals with MCI, which diminished the cognitive difference between the studied groups. This might explain the lower AUC compared with other studies. When patients with a diagnosis of MCI were excluded from the group "Other diagnoses," the AUC increased to 0.93 for RUDAS-S and 0.84 for MMSE-SR.

Nielsen and Jørgensen [16] reported in their meta-analysis that about 60% of the studies had a cutoff score of 23/24. Based on results of sensitivity, specificity, and accuracy in the present study, the optimal cutoff score for RUDAS-S was <25. This result was the same as in a cross-European memory clinic study that also included patients from Southern Sweden [17]. At a cutoff <25, we found the RUDAS-S to have a sensitivity of 0.92, a specificity of 0.60, and an accuracy of 76% (Table 6). Excluding patients with MCI from the analyses did not affect sensitivity, but increased specificity to 0.86, LR+ to 6.57, LR- to 0.15 and accuracy to 90%. When the group "other diagnoses" (not dementia) was purified as much as possible, there was a better balance between sensitivity and specificity and a higher accuracy. This could be due to the fact that MCI patients are in the borderland between dementia and non-dementia.

For a useful cognitive screening test, higher sensitivity is prioritized together with a high accuracy.

The high sensitivity indicates that RUDAS-S is a valuable cognitive screening instrument for detecting dementia. Due to lower specificity, clinicians should be aware of a fairly high rate of false positives.

#### *Strengths and weaknesses*

The present study is the first to validate the RUDAS-S in Sweden. The study was performed in daily clinical practice in 4 specialized memory clinics. To be inclusive and reflect real life, no exclusion criteria were formulated. The study included patients with different mother tongues and cultural backgrounds. This means that our study shows a spread of ethnicities, representative of the most common foreign-born groups in Sweden.

The study reflects the reality of patients in memory clinic settings. In general, the number of foreign-born patients who are referred for a cognitive assessment is smaller than expected. The proportion of NNS in the study was lower than NS but higher than the proportion of NNS in the general Swedish population. Foreign born patients seek care for memory disorders to a lesser extent than native born patients [8], which may indicate a need to increase knowledge about dementia and cognitive assessment in the group of foreign-born patients. Another advantage was that the included groups (NNS and NS), were demographically similar except for years of education, although this difference was not large. Before and during the study, the health professionals received training and supervision in the administration of the RUDAS-S and interpreter-mediated cognitive assessment. This may have been important for the tests to be carried out equally and for the results to be interpreted more coherently.

The study also has some limitations that should be considered. The study was of a cross-sectional cohort without longitudinal follow-up to support the accuracy of the clinical dementia diagnosis used as a criterion standard. The memory clinics in the study were accustomed to using the MMSE-SR and results from the MMSE-SR used to reach the dementia diagnosis were used as the criterion standard in the study. This may have inflated the psychometric properties for the MMSE-SR because of the circular argumentation. It would have been useful to use an independent measurement to evaluate the level of cognitive impairment such as the clinical dementia rating scale [42]. Another alternative would have been to examine the diagnostic accuracy of RUDAS-

S for detecting dementia without comparing it to MMSE-SR.

It can also be discussed whether the test results were affected by prioritizing testing with MMSE-SR over RUDAS-S, and if there were possible practice effects for MMSE-SR since most participants were tested with MMSE before being referred to specialist clinics. Still there were differences in MMSE-SR scores between NNS and NS patients

In this study, we compared test results and test properties in patients diagnosed with dementia and those with another diagnosis. Other studies often compared their study material results with results from healthy controls. On the one hand, this may also have been desirable here because we found that the AUC increased when the MCI group was excluded from those without dementia. On the other hand, our study design may better reflect clinical reality, whereas more “pure” case-control studies artificially may inflate diagnostic accuracy.

However, it should be noted that the diagnostic process was not blinded as MMSE-SR was part of clinical routine. To improve clinical diagnostics, it would have been optimal for two independent physicians to make the diagnosis, however, some of the participating clinics have a system with a special diagnostic round where several physicians and other staff participate, and diagnoses are made in consensus. We believe that this improves the quality of the distinction between no dementia and different levels of cognitive disability, SCI, MCI, dementia.

The study is based on reality and reflects the patients seeking care for cognitive impairment. In our study most of NNS patients were from upper-middle income and high-income countries. It would have been interesting to have a more even distribution of patients in the different groups of economic classification, since it is known that people from low-income countries do not seek help for cognitive impairment to the expected extent [26].

In summary, the present study showed that RUDAS-S, with an AUC of 0.81, had moderate to good diagnostic performance for detecting dementia in a multicultural population in Sweden. At a cutoff score <25 the sensitivity was 0.92, the specificity 0.60, and the accuracy 76%. The low specificity could represent a challenge if RUDAS-S was applied for screening in a normal population or case-finding in primary care where the prevalence of dementia can be low. In the memory clinic setting, RUDAS-S should not be used as a standalone measure of cognitive function to detect dementia. Promising

cross-cultural cognitive tools to support the RUDAS-S include extended cognitive screening with the MCE and neuropsychological testing with the CNTB, which have both been validated in ethnic minority and majority populations across several European countries. Against the background of increasing age and following cognitive deficits, and a growing proportion of immigrants in Sweden and other European countries, several valid cross-cultural cognitive tests are considered important. The RUDAS-S is a valuable cognitive screening instrument in clinical practice.

### Conclusion

The RUDAS-S was at least as accurate as the MMSE-SR in detecting dementia in a multicultural outpatient memory clinic patient sample in Sweden and the RUDAS-S can be used validly with all patients undergoing a cognitive assessment, irrespective of their cultural, language, and educational background. However, there is a need for other cross-cultural cognitive tests to complement the RUDAS-S for more extended cognitive examination, especially for assessing patients with nonnative language and cultural backgrounds.

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