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A review of the Rowland Universal Dementia Assessment Scale

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Abstract

Objectives: To explore the application, diagnostic accuracy and predictors effecting the performance of the Rowland Universal Dementia Assessment Scale (RUDAS) in older populations living outside Australia.

Design: A literature review was conducted using a simplified approach of thematic analysis. A comprehensive computerized search of peer reviewed published papers (2004–2017) was conducted in Academic Search Complete (EBSCO), Medline with Full-text, Pubmed and Google Scholar using the following search terms: *Rowland Universal Dementia Assessment Scale, sensitivity and specificity*. Inclusion criteria were papers in which the RUDAS was used with older populations outside Australia and written in English.

Results: Database and manual searching identified a total of 289 papers and after reviewing the abstracts, titles and full-text papers, 12 papers were included in this review. Outside the target populations of culturally and linguistically diverse communities in Australia, the RUDAS is applied internationally in Asia, Europe and Africa. The psychometric properties of the RUDAS were measured across these non-target population groups: sensitivity and specificity means, respectively were 80.9 (SD ± 6.24 ; 95% CI) and 76.1 (SD ± 12.2 ; 95% CI); RUDAS-MMSE mean correlation was 0.70 (SD ± 0.14 ; 95% CI) and mean AUC (area under curve) for RUDAS was 0.83 (SD ± 0.08 ; 95% CI).

Conclusions: Findings from this literature review showed that the RUDAS has strong psychometric properties across many population groups who are culturally and linguistically diverse in several countries. These findings provide support to undertake further research to evaluate the use of the RUDAS within culturally and linguistically diverse communities in other countries.

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KEYWORDS: *dementia, cognitive function, screening, Mini Mental State Examination, transcultural*

INTRODUCTION

Worldwide, the number of people living with dementia in 2015 was estimated at 46.8 million, and it is expected to reach 74.7 million in 2030 and 131.5 million in 2050 (Alzheimer Disease International, 2015). Dementia contributed to 11.2% of years lived with disability in people aged 60 years and older; more than stroke (9.5%), musculoskeletal disorders (8.9%), cardiovascular disease (5.0%), and all forms of cancer (2.4%) (Alzheimer Disease International, 2013). The costs of dementia worldwide were estimated at US\$ 818 in 2015, and it will reach US\$ 1 trillion by 2018 and US\$ 2 trillion by 2030 (Alzheimer Disease International, 2015). As with other diseases, the burden might be reduced through personalized interventions delivered at early stages of the disease, increasing demand for an accurate dementia assessment tool.

An important issue which is crucial in dementia care is how we assess for dementia. One of the most commonly used and well validated and reliable tools for assessing dementia is the Mini Mental State Examination (MMSE). The MMSE is used across the world by clinicians to assess dementia despite the range of evidence that the MMSE is flawed when used outside its target group. The MMSE is highly verbal in nature and not every item of the MMSE has the equal capability of assessing dementia. MMSE scores are effected by various demographic variables, including age (Escobar et al., 1986; Tombaugh and McIntyre, 1992), education (Escobar et al., 1986; Tombaugh and McIntyre, 1992) and cultural and linguistic background (Escobar et al., 1986; Tombaugh and McIntyre, 1992), language of interview (Escobar et al., 1986; Pang et al., 2009), gender and socioeconomic status (Pang et al., 2009).

Diagnosing dementia is particularly difficult for culturally heterogeneous populations because no gold standard diagnostic tools was developed specifically for these population groups (Basic et al., 2009a). Attempts to address this issue were made with the development of alternative

dementia assessment tools, including translated versions of the MMSE, Clock Drawing Test, Montreal Cognitive Assessment, General Practitioner Assessment of Cognition (GPCOG) (Brodaty et al., 2004), Mini-Cog and Memory Impairment Screen. An alternative dementia assessment tool used within culturally and linguistically diverse communities in Australia, the Rowland Universal Dementia Assessment Scale (RUDAS), was developed for culturally and linguistically diverse population (Storey et al., 2004). The RUDAS has high reliability and validity (Basic et al., 2009a). The items in the RUDAS address some of the flaws of the MMSE used within culturally and linguistically diverse communities.

The RUDAS is a six-item tool which is portable and requires no special equipment for its administration. It can be administered by health care workers after approximately 40 minutes of video training (Storey et al., 2004). The sensitivity and specificity of the tool, respectively are strong at 89 and 98 with a cut-off point of 23 (maximum score of 30 points) (Storey et al., 2004). The area under the ROC curve for the RUDAS was 0.94 with high inter-rater and test-retest reliability (respectively 0.99 and 0.98) (Storey et al., 2004). Since its development, researchers have measured the effects of the RUDAS across Australia (Rowland et al., 2006; Basic et al., 2009a, b; Pang et al., 2009; Goncalves et al., 2011) and outside Australia (Naqvi et al., 2015). In Australia, the RUDAS is validated in seven (7) different groups of language background, consisting of English (Storey et al., 2004, Basic et al., 2009a, b; Rowland et al., 2006; Pang et al., 2009; Goncalves et al., 2011), Asian, European (Pang et al., 2009), African, South American, Middle East (Rowland et al., 2006; Basic et al., 2009a) and Chinese (Pang et al., 2009) communities. In addition, the RUDAS was validated for use within Aboriginal and Torres Strait Islander indigenous communities in Sydney, NSW (Radford et al., 2015).

For this review study, the findings from each of the papers reviewed was pooled and the mean psychometric properties were calculated. The mean sensitivity and specificity of the RUDAS in

Australia, respectively, was 71.4 (SD $\pm$ 9.5; 95% CI) and 84.1 (SD $\pm$ 12.1; 95% CI), reflecting the high reliability of the RUDAS to assess dementia in culturally and linguistically diverse communities (Rowland et al., 2006; Basic et al., 2009a, b and Pang et al., 2009). In the original RUDAS study age significantly effected the RUDAS scores ($p = 0.04$) but other demographic factors did not, such as gender ($p = 0.18$), years of education ($p = 0.20$) and preferred language (English or otherwise) ($p = 0.33$) (Storey et al., 2004). More recent Australian studies also found that education (Rowland et al., 2006, Basic et al., 2009a ($p = 0.44$); Basic et al., 2009b ($p = 0.87$)) and gender (Rowland et al., 2006, Basic et al., 2009a ($p = 0.48$); Basic et al., 2009b ($p = 0.73$)) did not significantly effect the RUDAS performance. However, in the study of the RUDAS in an Aboriginal Australian community, years of education ($p = 0.07$) and female gender ($p = 0.08$) were effecting the RUDAS performance but age was not ($p = 0.42$) (Radford et al, 2015).

Measuring the use of the RUDAS in its target populations in Australia showed that culturally and linguistically diverse status ($p = 0.57$) and depression assessed by a Geriatric Depression Scale (GDS) score of > 5 ($p = 0.08$) did not influence the ability of the RUDAS to detect dementia (Basic et al., 2009a). In addition, the RUDAS performance was not significantly effected by the preferred language of the respondents (Storey et al., 2004; $p = 0.33$; Rowland et al., 2006 & Goncalves et al., 2011; $p = 0.3$). In Australia, the original RUDAS study was conducted with older people from an outpatient clinic (Storey et al., 2004), memory clinics (Basic et al., 2009a, b and Goncalves et al., 2011) and hospital settings (Pang et al., 2009). Patients ($n=46$) and clinicians ($n=12$) in Australia were asked to rate their preference for using the RUDAS compared to the MMSE. Slightly more patients preferred using the MMSE (15% and 13%, respectively), most indicated no preference (61%) and a few indicated no preference (9%) (Pang et al., 2009). Similarly, the clinicians preferred using the MMSE over the RUDAS (50% versus 8%, respectively). The main reason for preferring the MMSE was because they were more familiar with it than the RUDAS (Pang et al., 2009).

A previous systematic review on psychometric properties of the RUDAS was conducted by Naqvi et al. (2015). The paper reviewed 11 papers which reported measurement of the RUDAS both within and outside its target population in Australia (Naqvi et al., 2015). This review study added seven (7) papers to the papers reviewed by Naqvi et al. (2015), all of which had reports on sensitivity and specificity of the RUDAS. Two (2) papers reviewed by Naqvi et al were also included in this review study i.e. the papers by Iype et al. (2013) and by Shaaban et al. (2006). In addition, the Naqvi study did not compare the RUDAS to other cognitive assessment tools, while this review study compared the RUDAS to other assessment tool, which is the MMSE.

It is suggested that the RUDAS is the best stand-alone dementia assessment tool, not requiring an informant to provide proxy information and history for an individual, for use within culturally and linguistically diverse communities in Australia (Basic et al., 2009a). Our aim was to discover whether this assertion stands true for the use of the RUDAS with culturally and linguistically diverse communities in other countries. The objectives of this study were to explore the application, diagnostic accuracy and predictors effecting the performance of the RUDAS, which was developed for older populations in culturally and linguistically diverse communities in Australia, in older populations living outside Australia.

METHODS

This study was a literature review. Ethical approval for this literature review was received from Mochtar Riady Institute for Nanotechnology. A comprehensive computerized search of peer-reviewed published papers (2004-2017) was conducted in Academic Search Complete (EBSCO), Medline with Full-text, PubMed, and Google Scholar using the following search terms: *the Rowland Universal Dementia Assessment Scale, sensitivity and specificity*. The

literature search inclusion criteria were: (i) adult populations (>18 years) assessed with the RUDAS, (ii) measured diagnostic and psychometric properties (iii) all study designs as long as original data were used, (iv) papers published in English, (v) application of the RUDAS outside Australia. Exclusion criteria were: (i) papers not using the RUDAS in its entirety and (ii) papers that did not involve direct interview with participants, (iii) papers solely focused on culturally and linguistically diverse or Aboriginal and Torres Strait Islander communities in Australia. This literature review was conducted using a simplified approach of thematic analysis (Aveyard, 2014).

A total of 288 papers were retrieved through searching the databases and one (1) paper from manual searches of references. A total of 185 papers were excluded: 169 did not address the RUDAS in its entirety, 2 were opinion pieces, 2 did not report diagnostic and psychometric properties, 7 were review reports and 5 were written in non-English languages. Of the 20 papers identified as relevant, 2 involved the RUDAS administration via videoconference and five (5) addressed the RUDAS in targeted population within Australia, and one (1) measured the RUDAS in Aboriginal and Torres Strait Islander communities in Australia, leaving only 12 papers reviewed (60% of the identified papers). All titles and abstracts of papers were reviewed independently by the three authors, who met as a group and then with the primary author to discuss and agree on what papers to include in the literature review. From the 289 papers, 12 papers were critically reviewed (Figure 1). The quality of papers was evaluated by authors using critical appraisal tools (Aveyard, 2014).

Figure 1: PRISMA Flowchart of included and excluded papers

RESULTS

Measuring the use of the RUDAS in its targeted population in Australia within culturally and linguistically diverse communities found that it is a valid and reliable tool for assessing for dementia (Storey et al., 2004, Rowland et al., 2006; Basic et al., 2009a, b). This study reviewed the validity and reliability of the RUDAS outside the target populations of culturally and linguistically diverse communities in Australia. Translations of the RUDAS are available in 30 countries and the translations were possible with only minor edits to the content of individual items (Storey et al., 2004). Outside its targeted population in Australia, this study found the RUDAS available in 7 (seven) languages: Arabic, Malay, Malayalam (India), Chinese, Spanish, Thai, Turkish. Outside Australia, the RUDAS is available across four continents: Africa, Asia, Europe, and Oceania across 10 countries: Denmark (Nielsen et al., 2012; 2013), India (Iype et al., 2006), Lebanon (Nielsen et al., 2016), Malaysia (Shaaban et al., 2013), Middle East (Nielsen et al., 2016, Chaaya et al., 2015), New Zealand (Cheung et al., 2015), North Africa (Chaaya et al., 2015, Nielsen et al., 2016), Spain (Matias-Guiu et al., 2017, Mateos-Alvares et al., 2017), Taiwan (Chen et al., 2015) and Thailand (Limpawattana et al., 2012a, b). The findings from this review study of using the RUDAS outside Australia generated five (5) themes: diagnostic and psychometric properties of the RUDAS in non-target populations, application of the RUDAS in clinical settings in non-target populations, the RUDAS compared with well validated and reliable dementia assessment tools in non-target populations, demographic factors effecting the RUDAS performance in non-target populations, and comorbidities effecting the RUDAS performance in non-target populations.

1. Diagnostic and psychometric properties of the RUDAS in non-target populations

Diagnostic properties were reported in all studies reviewed (Table 1). The sensitivity and specificity of the RUDAS was reported in all but one of the 12 studies (Nielsen et al., 2012). Lowest sensitivity of the RUDAS (< 0.70) were reported in a study in Denmark (69; 0.57-0.79)

(Nielsen et al., 2013)). However, the mean sensitivity of the RUDAS across the studies was 80.9 (SD $\pm$ 6.2; 95% CI), indicating good (higher than 70%) sensitivity for the RUDAS. The RUDAS clearly has good capability to exclude populations with no dementia.

With regards to specificity, reports were more varied across countries than the sensitivity measurements. The mean specificity of the RUDAS was 76.1 (SD $\pm$ 12.2; 95% CI), with lowest specificity of 51 in Malaysia (Shaaban et al., 2013). While the Denmark study showed low sensitivity of the RUDAS, the area under curve (AUC) of the RUDAS in Denmark was 0.83, which is similar to mean AUC of the RUDAS, indicating a good discriminating ability of the RUDAS (see Table 1).

Regarding the psychometric properties, three (3) of the studies reported the validity and reliability of the RUDAS (Shaaban et al., 2013; Limpawattana et al., 2012b; Chen et al., 2015), all of which exhibited satisfactory measures of the RUDAS. The Malayalam-RUDAS item in South India exhibited good intra-rater reliability (ICC 0.71) (Shaaban et al., 2013). Similarly, measuring the use of the Chinese version of the RUDAS (RUDAS-C) in Taiwan also demonstrated good results (a test-retest reliability of 0.90, internal consistency reliability of 0.71, inter-rater reliability (kappa value) of 0.88 and a content validity index of 0.97) (Chen et al., 2015), showing consistent evidence of good internal consistency of the RUDAS items. In addition, the RUDAS-C had the capability to significantly differentiate between healthy older people and those with dementia ($t= 11.4$, p value <0.001).

Table 1. Diagnostic properties of the RUDAS

AUTHOR (YEAR)	LANGUAGE: COUNTRY	SENSITIVITY	SPECIFICITY	RUDAS-MMSE CORRELATION	AUC RUDAS	AUC MMSE
1. Iype et al. (2006)	Malayalam: India	88.0	76.0			
2. Shaaban et al. (2013)	Malay: Malaysia	80.0	51.0	0.63	0.64	0.59
3. Limpawattana et al. (2012a)	Thai: Thailand	78.7	60.7	0.81	0.81	0.81
4. Limpawattana et al. (2012b)	Thai: Thailand	78.7	61.8		0.82	
5. Nielsen et al. (2012)	Turkish: Denmark			0.40		
6. Nielsen et al. (2013)	Middle Eastern, Asian, European, American, African people; Denmark	69.0	80.0	0.73	0.83	0.84
7. Nielsen et al. (2016)	Arabic: Middle East, North Africa	82.0	84.0		0.92	
8. Chen et al. (2015)	Chinese: Taiwan	76.0	81.0	0.78		
		79.0	91.0	0.85		
9. Cheung et al. (2015)	European, Maori, Asian: New Zealand	78.4	85.1		0.86	
10. Chaaya et al. (2015)	Arabic: Middle East, North Africa	83	85		0.84	
11. Matias-Guiu et al. (2017)	Spanish: Spain	83.7	85.2	0.72	0.88	0.87
12. Mateos-Alvarez et al. (2017)	Spanish: Spain	94.3	72.6	0.71	0.9	0.88
Mean		80.0	76.1	0.70	0.83	0.79
Standard Deviation		6.2	12.2	0.13	0.08	0.11

2. Application of the RUDAS in clinical settings among non-target populations

Most of the studies recruited their sample of older people from clinical settings: hospital-based primary care clinics (Chen et al., 2015; Chaaya et al., 2015; Nielsen et al., 2016; Shaaban et al., 2013); geriatric clinics and neurology clinics (Chaaya et al., 2015; Chen et al., 2015; Limpawattana et al., 2012a; b; Nielsen et al., 2016; Matias-Guiu et al., 2017); a dementia clinic (Iype et al., 2006); a geriatric psychiatric department (Chen et al., 2015); a psychogeriatric clinic (Mateos-Alvarez et al., 2017); and memory clinics (Basic et al., 2009a; Nielsen et al., 2013). Some studies evaluating the RUDAS were undertaken in social organizations for the older people living in the community (Nielsen et al., 2016; Chaaya et al., 2015). One (1) study involved community-dwelling older people (Cheung et al., 2015).

3. The RUDAS compared with well validated and reliable dementia assessment tools in non-target populations

Amongst the twelve (12) studies reviewed, seven (7) compared the performance of the RUDAS with the MMSE (Nielsen et al., 2012, 2013; Shaaban et al., 2013; Limpawattana et al., 2012a, b; Matias-Guiu et al., 2017; Mateos-Alvarez et al., 2017). The mean correlation of the RUDAS and the MMSE in non-target populations was 0.70; SD 0.13; 95% CI which showed high positive association between the two assessment tools. The RUDAS was therefore as valid as the MMSE at assessing dementia. The mean area under curve (AUC) of the RUDAS was slightly higher than the MMSE (0.83, SD ± 0.08 ; 95% CI for the RUDAS versus 0.79; SD ± 0.11 ; 95% CI). However, both assessment tools had an AUC of more than 70%, suggesting that both assessment tools accurately discriminate between populations with dementia and those with no dementia.

This review study found several benefits from using the RUDAS compared to the MMSE. It was easier to learn how to use the RUDAS than the MMSE (Mateos-Alvarez et al., 2017). With regards to demographic variables, the performance of the RUDAS was more effective in assessment of dementia. The RUDAS was not effected by gender ($p = 0.759$) compared to the MMSE ($p = 0.004$) (Nielsen et al., 2012) nor by years of schooling ($p = 0.136$) compared to the MMSE ($p < 0.0001$) ($r = 0.083$, $r = 0.432$, $p < 0.01$) (Matias-Guiu et al., 2017). Similarly, the RUDAS scores were not influenced by cultural and linguistic background ($p = 0.08$) compared to the MMSE ($p = 0.02$) (Nielsen et al., 2013). Cultural factors in the MMSE creates a bias which results in populations from culturally and linguistically backgrounds being more likely to be assessed as having dementia when they do not have dementia. The RUDAS had better diagnostic properties than the MMSE (AUC 0.869, 0.806-0.917 for the RUDAS versus 0.727 for the MMSE) (Matias-Guiu et al., 2017).

One (1) study compared the RUDAS and the MMSE with the Global Deterioration Scale (GDS) and Clinical Dementia Rating (CDR) and found that the RUDAS was correlated with GDS (-0.722 ; $p < 0.01$) and with CDR (-0.739 ; $p < 0.01$). Similarly, MMSE was correlated with GDS (-0.719 ; $p < 0.01$) and CDR (-0.728 ; $p < 0.01$) (Mateos-Alvarez et al., 2017). Another study combined the RUDAS with the Informant Questionnaire on Cognitive Decline, which is administered to family caregivers, with older people in Arabic speaking respondents in North Africa and Middle East. The diagnostic accuracy of the RUDAS increased with the addition of this tool to the dementia assessment (AUC value for the RUDAS used alone $z = -2.47$, $p = 0.014$) (Nielsen et al., 2016).

4. Demographic factors effecting the RUDAS performance in non-target populations

In twelve (12) of the studies reviewed, eight (61.5%) reported demographic predictors effecting the RUDAS performance: age, gender, years of education and cultural and linguistic background, presence of an informant (Nielsen et al., 2013), and recruitment location (Chaaya et al., 2015). Five (5) studies found an education bias in the RUDAS: Chaaya et al., 2015 (respective $p < 0.001$), Iype et al., 2006, Limpawattana et al., 2012b, Matias-Guiu et al., 2017 (Area under curve for 8 years schooling was 0.91 (0.852-0.973) compared to 0.874 (0.794-0.955) for 7 years schooling or less (Table 2); Nielsen et al., 2012.

Table 2. Effects of years of education on the performance of the RUDAS

AUTHORS	LANGUAGE: COUNTRY	P VALUE	DIFFERENCE (T TEST)	CORRELATION	LOGISTIC REGRESSION	STATISTICAL LEVEL OF SIGNIFICANCE	AREA UNDER CURVE
1. Iype et al. (2006)	Malayalam: India	<0.001	0.756	0.452			
2. Limpawattana et al. (2012b)	Thai: Thailand	<0.001				0.04	
3. Nielsen et al. (2012)	Turkish: Denmark	<0.001		0.002		0.236	
4. Nielsen et al. (2013)	Middle Eastern, Asian, European, American, African people; Denmark					0.31	
5. Chaaya et al. (2015)	Arabic: Middle East, North Africa	<0.001					
6. Matias-Guiu et al. (2017)	Spanish: Spain			No correlation			≥8 years schooling: 0.91 (0.852-0.973) ≤7 years schooling: 0.874 (0.794-0.955)
7. Mateos-Alvarez (2017)	Spanish: Spain	0.136		0.087	0.768 (-0.245, 1.782)		

Out of twelve (12) studies, six (6) measured effects of age on the RUDAS performance and found age significantly effected the performance of the RUDAS: within the Turkish respondents in Denmark ($\rho = -0.355$, $p = 0.002$) (Nielsen et al., 2012), Danish respondents in Denmark ($p < 0.001$) (Nielsen et al., 2013), Arabic respondents in Lebanon ($p < 0.001$) (Chaaya et al., 2015), and Spanish respondents in Spain (-0.359 , $p < 0.0001$) (Mateos-Alvarez et al., 2017). Two (2) studies reported that gender did not significantly effect the RUDAS performance (Limpawattana et al., 2012b; Nielsen et al., 2012), however, two (2) other studies found that gender created a bias in the use of the RUDAS: in Lebanon with Arabic respondents (Chaaya et al., 2015; $p = 0.23$) and with the Spanish respondents in Spain (Mateos-Alvarez et al., 2017; $\beta = 1.053$, $p = 0.811$).

Two (2) studies found significant effects in the cultural and linguistical background of respondents on the RUDAS performance ($p = 0.001$, Nielsen et al., 2012), ($p = 0.08$, Nielsen et al., 2013). One (1) study reported significant effects of informant presence on the RUDAS performance ($p < 0.001$) (Limpawattana et al., 2012a). However, the study in Danish memory clinic in Denmark showed the opposite ($p = 0.004$) (Nielsen et al., 2013). Only one (1) study showed that recruitment location effected the RUDAS performance ($p < 0.001$, Chaaya et al., 2015).

5. Comorbidities effecting the RUDAS performance

Two (2) studies measured the effect of depression and found no significant effect of depression on the RUDAS scores (Chaaya et al., 2015; $p = 0.882$; Limpawattana et al., 2012a, $p = 1.00$). Depression was assessed using the Geriatric Mental State (GMS) in the study by Chaaya et al. (2015), but measurement tool to assess depression was not reported in the study by Limpawattana. The activity of daily life as assessed by Lawton scores effected the RUDAS scores ($p = 0.04$, Limpawattana et al., 2012b).

DISCUSSION

The RUDAS is a dementia assessment tool aimed at assessing dementia in older people from culturally linguistic communities in Australia. Researchers, from around the world, have adapted the RUDAS, translated it into the language of their country and found that without changing the structure of the RUDAS items it is valid and reliable for their communities (Storey et al., 2004). This review study provided a summary of the research evidence relating to the application, diagnostic accuracy and predictors effecting the performance of the RUDAS adaption across many different countries. The results showed that the RUDAS had strong diagnostic properties, as showed by the RUDAS mean sensitivity and specificity. Compared to a previous systematic review and meta-analysis involving 11 studies of the RUDAS in countries across the world by Naqvi et al. (2012), this review study showed higher sensitivity (80.0 versus 77.2) but lower specificity (76.1 versus 85.9) of the RUDAS.

Shorter years of education among the non-target population of the RUDAS effected the performance of the RUDAS (Limpawattana et al., 2012a, Nielsen et al., 2012), which differed from the original studies of using the RUDAS in Australia where the respondents had more than six years of education (Storey et al., 2004). In the Thailand study, a large percentage of the respondents (97 out of 200) (47%) were older people attending geriatric outpatient clinics with only six years of education or lower (Limpawattana et al., 2012a). Similarly, in the Malay study, 61.2% of the 49 older respondents had only primary or no formal education (Shaaban et al., 2013). In the Denmark study, the mean formal education of the recruited sample was 3.9 years out of which one third ($n = 67$) were illiterate. Another possible explanation for the low discriminating ability of the RUDAS outside Australia could be the small sample size respondents in the Malay study ($n=49$) (Shaaban et al., 2013) and in the Denmark study ($n=76$)

(Nielsen et al., 2012) and involvement of older people with mild cognitive impairment in the Malay study (Shaaban et al., 2013), which was in contrast with involvement of two groups of normal older people and older people with dementia in the Australian RUDAS study (Rowland et al., 2006).

This review study showed high and positive correlation between the RUDAS and the MMSE (0.70; SD 0.13; 95% CI), reflecting equal accuracy of the RUDAS in predicting dementia as the MMSE. This is lower than the pooled estimate of the RUDAS-MMSE correlation reported in a previous systematic review, which was 0.77; SD 0.72-0.83 95% CI) (Naqvi et al., 2015). However the study by Naqvi et al. (2012) reviewed RUDAS assessment both inside and outside its target population in Australia, whereas this study reviewed articles on the RUDAS assessment outside Australia. Despite moderate correlation of the RUDAS and the MMSE, this review study showed high mean area under curve (AUC) of the RUDAS (0.83, SD $\pm$ 0.08; 95% CI) when it was used outside Australia, confirming strong diagnostic properties of the adapted translated versions of the RUDAS to assess dementia. The AUC suggested the diagnostic accuracy of an assessment tool against the gold standard (Limpawattana et al., 2012a). An AUC between 0.9 and 1.0 indicated 'excellent' accuracy, 0.8 to 0.9 as 'good', 0.7 to 0.8 as 'not good', and 0.6 to 0.7 as 'worthless'. In evaluating the performance of a diagnostic test, ROC curve analysis is used as an effective, unbiased method to show the relationship between sensitivity and specificity (Zhu, 2010 as cited in Cheung et al., 2015) and the higher values of the AUC value, the better is the performance (Basic et al., 2009a). When the RUDAS is adapted for use in culturally and linguistically diverse populations outside Australia, it is an effective dementia assessment tool.

Three (3) of the studies reviewed measured the psychometric properties of the RUDAS (Shaaban et al., 2013; Limpawattana et al., 2012b, Chen et al., 2015) and all of them generated

satisfactory measures of the RUDAS in line with the good inter-rater (Intraclass Correlation Coefficient; ICC=0.99) and test-retest reliability (ICC=0.98) demonstrated in the original RUDAS study (Storey et al., 2004). This indicated that the RUDAS had strong discriminating ability to rule in people with dementia from culturally and linguistically diverse communities outside Australia. The items of the adapted translated versions of the RUDAS had good internal consistency (Shaaban et al., 2013, Basic et al., 2009a, Chaaya et al., 2015) but the values were lower than the original RUDAS study (Intraclass Correlation Coefficient; ICC=0.99) (Storey et al., 2004).

The original RUDAS study reported that its assessment score was not influenced by years of education ($p = 0.2$) (Storey et al., 2004). Other RUDAS studies in Australia confirmed this finding (Rowland et al., 2006; $p = 0.44$ (Basic et al., 2009a); $p = 0.87$ (Basic et al., 2009b). However, in this review study, five (5) studies showed significant effects of education on the RUDAS scores for: South India (Iype et al., 2006), Thailand (Limpawattana et al., 2012b), Denmark (Turkish respondents) (Nielsen et al., 2012), in Middle East and North Africa (Arabic speaking respondents) (Chaaya et al., 2015), and Spain (Matias-Guiu et al., 2017). In the Spanish study, in particular, there was higher AUC of the RUDAS in the more educated group (a mean of 8 years of formal education) (Matias-Guiu et al., 2017). The same finding was found in the RUDAS study amongst Arabic respondents in Middle East and North Africa, where 51% of older people with no formal education had very low scores within the 'visuo-constructional item' as compared to 30% with primary to secondary education, and 4% with university education, indicating the RUDAS more challenging, particularly on, when the participants were asked to draw the cube (Chaaya et al., 2015). However, in these studies outside Australia, respondents with low levels of education had higher scores in the RUDAS than the MMSE (Shaaban et al., 2013, Limpawattana et al., 2012a, and Mateos-Alvarez et al., 2017). There was also more variance from years of education on MMSE scores as compared to the RUDAS

scores (44% versus 16%) within the Turkish respondents in Denmark; shorter years of education showed less educational bias for the RUDAS than the MMSE (Nielsen et al., 2012). Hence, further investigation is needed to find out whether specific items on the RUDAS are dependent on levels of education and are poorly performed by healthy people with low levels of literacy (Matias-Guiu et al., 2017).

This review study revealed that age significantly effected the RUDAS score, as evident in the study of Turkish respondents in Denmark (Nielsen et al., 2012), Danish respondents in Denmark (Nielsen et al., 2013), in Arabic respondents in Lebanon (Chaaya et al., 2015), and in Spain (Mateos-Alvarez et al., 2017). This was in line with the original RUDAS study in Australia ($p = .04$, Storey et al., 2004), but in contrast with other RUDAS studies in Australia which reported that age did not effect the RUDAS performance (Rowland et al., 2006; $p = 0.5$, Basic et al., 2009a; $p = 0.65$, Basic et al., 2009b; $p = 0.42$, Radford et al., 2015). Regarding gender, this review study showed that gender did not significantly effect the RUDAS performance, as reported in the study with Turkish respondents in Denmark (Nielsen et al., 2012) and in the Thailand study (Limpawattana et al., 2012b). These findings were in line with findings from previous RUDAS studies in Australia that gender did not effect the outcome of RUDAS scores ($p = 0.18$, Storey et al., 2004; Rowland et al., 2006; $p = 0.48$, Basic et al., 2009a; $p = 0.73$, Basic et al., 2009b). However, this finding was in contrast with the RUDAS study with the Aboriginal and Torres Strait Islander respondents which showed that gender effected the RUDAS performance ($p = 0.08$, Radford et al., 2015).

With regards to demographic variables, this review study demonstrated that when adapted RUDAS is used outside Australia it is less effected by language, education levels, age and gender than the MMSE; that is the RUDAS generated less bias than the MMSE when used in culturally and linguistically diverse communities outside Australia (Nielsen et al., 2012; 2013).

Culturally and linguistically diverse background (CALD) effected the RUDAS performance ($p = 0.001$, Nielsen et al., 2012; 2013), which confirmed the findings from the original RUDAS study (Storey et al., 2004). However, this finding was contrary to the previous RUDAS studies in Australia which showed that CALD status did not effect RUDAS scores ($p = 0.57$, Basic et al., 2009a; $p = 0.76$, 2009b). It should be noted, however, that Basic et al. (2009a, b) studies used 151 respondents with different cognitive status (dementia, normal, and CIND [cognitive impairment not dementia]) whereas the international studies were smaller and less diverse cohorts than this. Activity of daily life, as assessed by Lawton scores, was also measured in studies of the RUDAS in Australia and outside Australia. The studies outside Australia showed that activity of daily living scores had significant effects on the RUDAS scores (Limpawattana et al., 2012b) which matched findings from the RUDAS studies in Australia (Basic et al., 2009b). Two studies identified that depression had no significant effect on the RUDAS scores (Chaaya et al., 2015; Limpawattana et al., 2012a) which again supported findings from the RUDAS studies in Australia (Basic et al., 2009a). Therefore, decisions about using the RUDAS as a dementia assessment tool outside Australia need to consider the demographic profiles and comorbidities of the population groups.

There are likely to be several reasons for the RUDAS being more reliable with culturally and linguistically diverse communities than the MMSE, for example, the use of images in the RUDAS which makes the tasks in the RUDAS easier to complete for respondents than the MMSE and the six category items assessing body orientation, praxis, drawing, judgment, memory, and language. The diagnosis of dementia was argued to significantly associate with “4-item grocery recall”, “crossing the road”, “cube copying” and animal generation” which do not rely the higher level cognitive skills required in the MMSE (Storey et al., 2004). The RUDAS does not require as much reading which makes it useful for population groups from culturally and linguistically diverse communities (Naqvi et al., 2012).

Strengths and Limitations

This review study provides a comprehensive review of the literatures from an extensive search of several databases and reviewed all relevant studies. The overall quality of the studies that assessed the psychometric properties of the RUDAS was good.

There were several limitations to this review study. One of the inclusion criteria was articles published in English which decreased the number of articles included in the review. This decision was made as there was no funding available to translate any papers not published in English. With regards to the study results, only one (1) study measured test-retest reliability and only three (3) studies focused on internal consistency of the RUDAS when determining whether the adapted versions of the RUDAS were suitable for assessing dementia in their target populations of culturally and linguistically diverse communities outside Australia. Generalisability of the findings might not be possible from this review because all studies undertaken in non-English speaking population groups utilized formal interpreters in clinical and community settings. It was not possible in this review to fully measure the accuracy of the respondents' responses to the RUDAS. Finally, this study compared the RUDAS with other cognitive assessment tools, for example, the MMSE, Global Deterioration Scale (GDS) and Clinical Dementia Rating (CDR). While GDS and CDR can be used to differentiate specific types of dementia and its severity the RUDAS can not be used to do this. Clinicians and researchers need to consider the goals for the work they are doing with consumers before making decisions about using the RUDAS on its own. Sometimes, the GDS, CDR or another assessment tool might be needed to complement results gained from the RUDAS if there is a need to identify a specific type of dementia.

Conclusions

The RUDAS is an effective and efficient tool that was adapted for use culturally and linguistically diverse communities across the world for assessing dementia because of its strong psychometric properties. The papers reviewed in this study were conducted in diverse countries and continents utilizing wide variety of languages and assessed different demographic predictors effecting the RUDAS performance, thus adding to the generalizability of the review results. This review study also described advantages of the RUDAS as compared to the more commonly used dementia assessment tool, the MMSE. As the number of the ageing population over the age of 65 years across the world predicted to double in the next decade, the RUDAS as a culturally practical tool to assess dementia will increasingly be more important and has the potential for improved utility into a larger population.

One of the purposes of this review study was to inform a decision about whether to undertake research in Indonesia to adapt the RUDAS for populations in Indonesia. The findings from this review provided convincing evidence that when the RUDAS is used in culturally and linguistically diverse communities outside Australia, the tool can be used to assess for dementia. Tests of the psychometric properties of RUDAS demonstrated that this assessment tool can be used confidently by clinicians in many different countries with culturally and linguistically diverse communities. In addition, usability testing provided evidence that the RUDAS is an acceptable assessment tool for individuals living with a dementia, family carers and clinicians. Next, these authors will extend their research and begin development of the RUDAS-Indonesian version to make a contribution to improving the assessment of dementia among Indonesian populations.

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DECLARATION OF CONFLICTING INTERESTS

The authors declare that there is no conflict of interest

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