Alzheimer's & Dementia: Translational Research & Clinical Interventions 5 (2019) 542-552

Featured Article

Diagnostic accuracy of a global cognitive screen for Māori and non-Māori octogenarians

Kristina Zawaly[a,*,1], Simon A. Moyes[a], Phil C. Wood[b,2], Gary Cheung[c], Anna Rolleston[d], Stephen Buetow[a], Lynette Tippett[e], Ngaire Kerse[a]

[a]*Department of General Practice & Primary Health Care, University of Auckland, Auckland, New Zealand*
[b]*Department of Medicine, University of Auckland, Auckland, New Zealand*
[c]*Department of Psychological Medicine, University of Auckland, University of Auckland, University of Auckland, Auckland, New Zealand*
[d]*The Centre for Health Ltd., Manawa Ora Centre, Tauranga, Bay of Plenty, New Zealand*
[e]*School of Psychology, University of Auckland, University of Auckland, Auckland, New Zealand*

Abstract

Introduction: We assessed the sensitivity and specificity of the Modified Mini–Mental State Examination (3MS) in predicting dementia and cognitive impairment in Māori (indigenous people of New Zealand) and non-Māori octogenarians.

Methods: A subsample of participants from *Life and Living in Advanced Age: a Cohort Study in New Zealand* were recruited to determine the 3MS diagnostic accuracy compared with the reference standard.

Results: Seventy-three participants (44% Māori) completed the 3MS and reference standard assessments. The 3MS demonstrated strong diagnostic accuracy to detect dementia with areas under the curve of 0.87 for Māori and 0.9 for non-Māori. Our cutoffs displayed ethnic variability and are approximately 5 points greater than those commonly applied. Cognitive impairment yielded low accuracy, and discriminatory power was not established.

Discussion: Cutoffs that are not age or ethnically appropriate may compromise the accuracy of cognitive screens. Consequently, older age and indigeneity increase the risk of mislabeled cognitive status.

Keywords: Assessment of cognitive disorders/dementia; Underserved populations; Sensitivity and specificity; Cognitive aging; Aged 80 and over

1. Introduction

Although cognitive screening tools are well suited to evaluate cognition, their accuracy and optimal cutoff values in octogenarian indigenous and non-indigenous populations are largely unknown. For the evaluation of cognition in New Zealand (NZ), tools derived and validated from Western English-speaking countries are used. Cultural lifestyle differences between NZ and countries that developed and validated the cognitive screening tools indicate it may be necessary to assess their diagnostic accuracy. The appropriateness of such screening tools is questionable for the indigenous population of NZ (Māori). It's possible that those who are disadvantaged and/or indigenous have higher rates of dementia than the general population [1–5]. Indigenous Australians were estimated to have a 5.2 times greater prevalence of dementia than the Australian population [6]. Prevalence of dementia is unknown for Māori. This is important because Māori are reported to perform at lower

The authors have declared that no conflict of interest exists.

[1]Department of Family Medicine, University of McGill, 5858 chemin de la Côte-des-Neiges, 3rd floor, Montréal, Québec, H3S 1Z1, Canada.
[2]Chief Advisor Healthy Aging, Ministry of Health, PB 5013, Wellington, 6140, New Zealand.
*Corresponding author. Tel.: +64 9 923 9628; Fax: +64 9 373 7624.
E-mail address: k.zawaly@auckland.ac.nz

https://doi.org/10.1016/j.trci.2019.08.006

cognitive levels than NZ Europeans [7] because of cultural bias in measures.

As age is the greatest nonmodifiable risk for dementia [8], octogenarians are vulnerable to this syndrome. It remains unclear how much age-related versus pathophysiological changes may contribute to the escalating rate of cognitive impairment [9].

The Modified Mini–Mental State Examination (3MS) [10] has not been previously validated for Māori and non-Māori octogenarians. The aim of this study was to determine the cutoff values of the 3MS in identification of dementia (vs. no dementia) and cognitive impairment (vs. normal cognition) through examining the diagnostic accuracy and to determine the criterion to validate the 3MS against a reference standard.

2. Methods

2.1. Participants

Participants were subsamples of Māori and non-Māori, who were part of a six-year multicentered longitudinal cohort study, *te puawaitanga o nga tapuwai kia ora tonu Life and Living in Advanced Age: a Cohort Study in NZ* (LiLACS NZ). LiLACS NZ was initiated to determine the predictors of successful advanced aging in Māori and non-Māori population-based cohorts. Kaupapa Māori methodology was used to engage and recruit a total population of eligible Māori participants [11]. The protocol for LiLACS NZ [11] recruitment and representativeness [12] has been described in detail elsewhere. In brief, LiLACS NZ recruited Māori aged 80–90 years and non-Māori aged 85 years, from the Bay of Plenty and Lakes regions (excluding Taupo) District Health Boards in the North Island of NZ in 2010. A wider age window was necessary for Māori to enable equal explanatory power between ethnicities because of lower life expectancy of Māori and lower population proportion (15% of the NZ population) [13]. A single year age group was selected for the non-Māori cohort to minimize the age effects. This prospective diagnostic accuracy study received ethics approval from the Northern Health and Disability Ethics Committee (NXT/10/12/128). The Standards for Reporting Diagnostic Accuracy [14] were followed, and Fig. 1 and Fig. 2 represent the study flowchart for Māori and non-Māori, respectively.

A study objective was to represent accurately the octogenarian population, and therefore recruitment was not compromised by applying extensive exclusion criteria, paralleling the parameters of clinicians [15]. Participants were excluded if they did not complete the full assessment, refused to complete the 3MS portion, dropped out of LiLACS NZ before being invited to participate in this study, or did not consent to be contacted about substudies. Assessing the validity of a cognitive screening tool requires a range of levels of cognition [16] (e.g., "normal" 3MS scores, 78 or above [17], and "abnormal" scores, either a 3MS score of $\leq$77 at any time point [17] or 3MS scores which decreased by $\geq$5 points between annual assessments [18]). The sample comprised an over sampling of those with "abnormal" scores and a randomly selected group of those with "normal" scores on the 3MS.

Blinded to the 3MS scores, local LiLACS NZ coordinators approached the potential participants by telephone, between June 2012 and January 2016, and invited them to participate. It was not possible to recruit/assess all potentially eligible participants from LiLACS NZ because of lack of availability of the trained dementia assessors and resources. Informed written consent was obtained from participants who agreed to participate or from the next of kin of those who lacked the capacity.

2.2. Data collection

To alleviate any cultural bias, Māori and non-Māori assessments were completed by Māori and non-Māori assessors, respectively. A face-to-face interviewer administered a standardized questionnaire that collected sociodemographic, speaking of te reo Māori, and health data on depressive symptoms [19] and a sum of comorbid conditions [20].

2.3. Index test

The 3MS is a brief cognitive screen, consisting of 27-items [21], and was not part of a diagnostic algorithm. It was conducted annually by a blinded trained assessor as part of LiLACS NZ standardized face-to-face assessment and took approximately 15 to 20 minutes to complete. To minimize the practice effects which can occur through short-interval retesting ($<$12 months), alternative word sets were used [21,22].

Similar to other cognitive screening tools, the 3MS relies on a participant's sensory and/or dexterity abilities to complete the assessment effectively. Participants with sensory impairments are more likely to score below normal cognitive function [23,24] and be identified as false positive. Sensory ability findings may be similar for dexterity, as they both negatively impact performance on cognitive screens that cannot differentiate between cognitive impairment and other types of disabilities. As there is currently no provision for adjusting scores for noncognitive disabilities on the 3MS, sensory and dexterity items were pragmatically selected based on previous research [24–26] and clinical experience. K.Z. and N.K. identified, reviewed, and discussed each case to reach consensus on noncognitive disability, in which case the score was adjusted upward.

2.4. Reference standard

The criterion for cognitive assessment standardized protocol was based on the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association [27] criteria and the

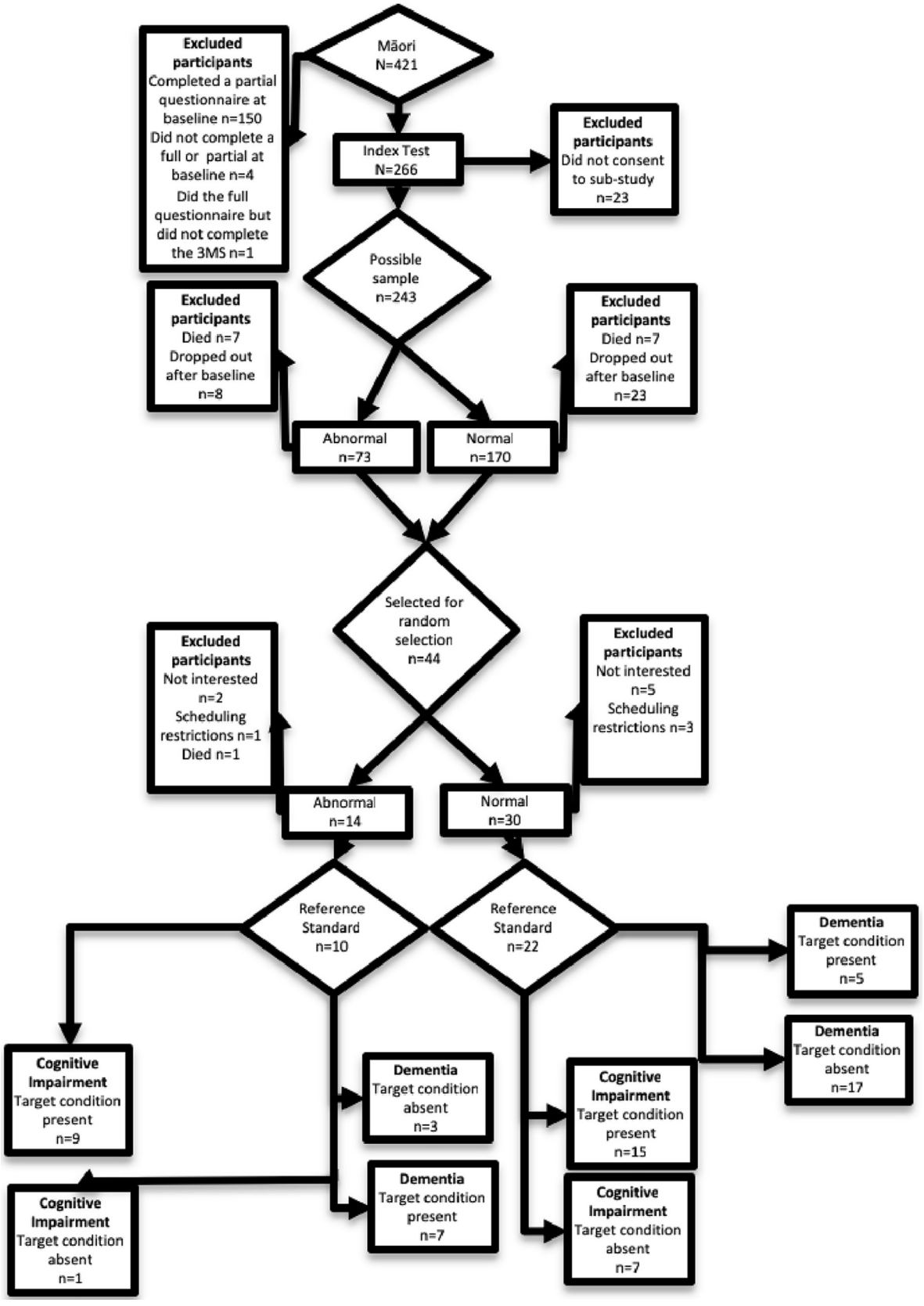

Fig. 1. Study flowchart Māori. Abbreviation: 3MS, Modified Mini–Mental State Examination.

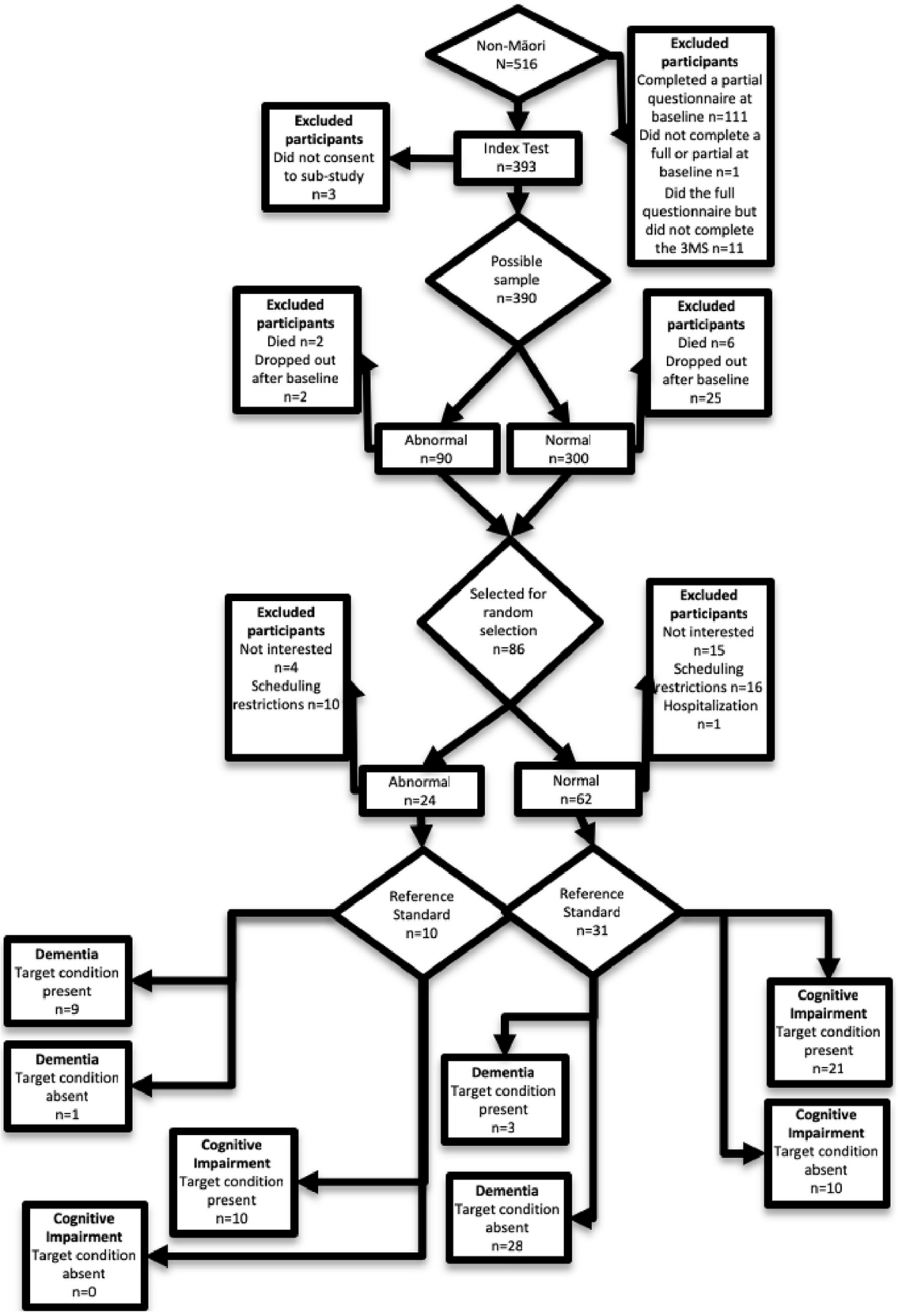

Fig. 2. Study flowchart non-Māori. Abbreviation: 3MS, Modified Mini–Mental State Examination.

American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders IV criteria for dementia [28]. Trained blinded dementia assessors (N.K., a family physician with additional geriatric training; P.C.W., a geriatrician specializing in dementia care; K.Z., a PhD holder with clinical cognitive assessment training, with supervision under N.K. or P.C.W.) applied the protocol during a face-to-face, culturally appropriate interview that accounted for hearing and visual disabilities as much as possible. The protocol, which comprised a clinical evaluation completed by K.Z., N.K., and P.C.W., included the integration of medical history, observation of the study participant, history talking from the participant and carer, results from other standardized cognitive screening tests (Addenbrooke's Cognitive Examination-Revised), and application of clinical judgment. After the clinical assessment, classification of cognitive function was determined by a blinded multidisciplinary consensus guided by the Clinical Dementia Rating Scale to provide the reference standard for normal cognition (0), mild cognitive impairment (MCI) (0.5), or dementia (1–3).

2.5. Timing of index test and reference standard

The time period varied between the index test and the reference standard assessment and was sometimes lengthy. To best account for this variability, which could have resulted in misclassification [29], the reference standard date was matched to the closest (before or after) index test of the participant. If the reference standard occurred more than 6 months after the index test, a linear trend was extrapolated from the two most proximal 3MS measures. However, if the reference standard occurred less than 6 months after the index test, a weighted average was imputed utilizing the two 3MS scores before and after the reference standard date.

Sensitivity analyses were conducted using the 3MS scores immediately preceding the reference standard and the 3MS score nearest to the reference standard (e.g., if the reference standard occurred three months after LiLACS NZ Wave three assessment, LiLACS NZ Wave three 3MS was used, but if the reference standard occurred nine months after LiLACS NZ Wave three 3MS, LiLACS NZ Wave four 3MS was used).

2.6. Analyses

Statistical Analysis Software (SAS), version 9.3 (SAS Institute Inc. Cary, NC), and R, version 3.5.1, were used for analyses. Once data collection and entry was completed from the Māori and non-Māori samples, they were analyzed separately to ensure the result would be relevant to each population [30].

Descriptive characteristics are presented as means and SDs or medians and interquartile range for continuous variables, and discrete variables are summarized by frequencies and percentages.

There were two planned comparisons of interest: (i) dementia versus no dementia (i.e., MCI and normal cognition combined) and (ii) cognitive impairment (i.e., dementia and MCI combined) versus normal cognition. The sample included in this study was used as the reference to calculate the estimated prevalence of syndromes in Māori and non-Māori. The existing binary 3MS test results were cross-tabulated with the binary reference standard. Receiver operating characteristics curves were used to analyze the diagnostic accuracy of the 3MS and discriminate between participants in each of the two comparisons. The cutoff values were selected from the curve to optimally balance the sensitivity (true positive) and specificity (true negative) [31,32]. The sensitivity and specificity were used to generate positive predictive value (PPV) and negative predictive value (NPV) with their 95% CIs. Also, positive likelihood ratio (LR+) and negative likelihood ratio (LR−) were determined, and diagnostic odds ratios were computed to assist in the assessment of the clinical value of the index test [33].

2.7. Sample size

The prevalence of cognitive impairment among Māori and non-Māori octogenarians in NZ is currently unknown [34]. This precluded formal calculation of sample size estimates to guide this study. Thus, the objective of this pragmatic diagnostic accuracy study was to recruit and assess as many participants as possible from the LiLACS NZ sample to gain the largest sample attainable.

3. Results

73 participants were recruited, and all had a full clinical assessment for the reference standard diagnosis.

Characteristics of the 73 participants stratified by the reference standard diagnosis are provided in Table 1. Almost half of the sample (44%, $n = 32$) self-identified as Māori. At the time of the reference standard, the mean age of Māori was 87.3 and the mean age for non-Māori was 87.0. More than half were female (Māori 72%; non-Māori 56%).

The proportions of participants with dementia assessed clinically were 38% (95% CI [21.10–56.31]) for Māori and 29% (95% CI [16.1–45.54]) for non-Māori. Table 2 A displays the cross-tabulation comparing the index test to the reference standard.

The results of the first receiver operating characteristic curve, shown in Fig. 3 A, assessed the ability of the 3MS to identify dementia compared to no dementia (i.e., MCI and normal cognition combined) in Māori and non-Māori. Optimal screening cutoff values for dementia of 80 and 84 were determined to maximize the sensitivity and specificity of the results for Māori and non-Māori, respectively. The lowest PPV of 0.69 was found for non-Māori with NPV of 0.96, LR+ 5.32, and LR− 0.10, with a high sensitivity of 0.83 and specificity of 0.80 (Table 3). Māori had the greatest

Table 1
Descriptive statistic characteristics of Māori and non-Māori

	Māori				Non-Māori			
Variable	All (n = 32)	Normal (n = 8)	MCI (n = 12)	Dementia (n = 12)	All (n = 41)	Normal (n = 18)	MCI (n = 11)	Dementia (n = 12)
Age, mean (SD)	87.3 (2.6)	87.8 (3.3)	87.2 (2.1)	87.1 (2.8)	87.0 (0.6)	87.0 (0.4)	87.0 (0.4)	87.2 (1.0)
Sex								
Female	23 (72)	5 (22)	9 (39)	9 (39)	23 (56)	11 (48)	8 (35)	4 (18)
Education								
None or primary school only	11 (34)	2 (18)	7 (64)	2 (18)	9 (22)	4 (44)	3 (33)	2 (22)
Secondary	18 (56)	6 (33)	5 (28)	7 (39)	28 (68)	11 (39)	7 (25)	10 (36)
Trade or tertiary	3 (9)	0 (0)	0 (0)	3 (100)	4 (10)	3 (75)	1 (25)	0 (0)
Marital status*								
Never married	1 (3)	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Married	7 (22)	2 (29)	1 (14)	4 (57)	21 (51)	9 (43)	4 (19)	8 (38)
Widow/widower	21 (66)	5 (24)	9 (43)	7 (33)	17 (41)	9 (53)	5 (29)	3 (18)
Separated/divorced	3 (9)	0 (0)	2 (67)	1 (33)	3 (5)	0 (0)	2 (67)	1 (33)
Living arrangement†								
Alone	14 (50)	5 (36)	6 (43)	3 (21)	16 (43)	8 (50)	6 (38)	2 (13)
Spouse/partner	8 (29)	3 (38)	1 (13)	4 (50)	16 (43)	6 (38)	4 (25)	6 (38)
Others	6 (21)	0 (0)	4 (67)	2 (33)	5 (14)	3 (60)	1 (20)	1 (20)
Speak te reo‡								
Yes	14 (50)	5 (36)	7 (50)	2 (14)	0 (0)	0 (0)	0 (0)	0 (0)
No	14 (50)	3 (21)	4 (29)	7 (50)	37 (100)	17 (46)	11 (30)	9 (24)
GDS (>5)	8 (25)	3 (38)	4 (50)	1 (13)	9 (22)	2 (22)	1 (11)	6 (67)
Comorbid conditions (out of 19) median (IQR)	5 (4)	5.5 (4)	6 (4)	4.5 (3)	5 (3)	5.5 (4)	5 (3)	4.5 (2.5)

NOTE. Data are mean (SD), median (IQR), or numbers, n (percent [%]).
Abbreviations: IQR, interquartile range; GDS-15, Geriatric Depression Scale; MCI, mild cognitive impairment.
*Missing in 2 Māori.
†Missing in 8 Māori and 4 non-Māori.
‡Missing in 4 Māori.

PPV of 0.83, with NPV of 0.90 but with the highest specificity of 0.90, as well as LR+ 8.3, and LR− 0.19 (Table 3). Our study has shown a substantial agreement in accuracy for diagnosing dementia in Māori and non-Māori with kappa values of 0.73 and 0.68, respectively at the optimal identified cutoff values.

In our sample, the proportion of Māori with cognitive impairment (i.e. dementia and MCI combined) was 75% (95% CI [30.76–78.47]) and it was 56% (95% CI [20.69–57.74]) for non-Māori. The cross-tabulations of the 3MS compared to the reference standard are shown in Table 2B.

Fig. 3B shows the second set of receiver operating characteristic analyzes conducted to assess the ability of the 3MS to differentiate between those with cognitive impairment and those with normal cognition in Māori and non-Māori. When the sensitivity and specificity were maximized, Māori had a cutoff value of 85 for cognitive impairment, with sensitivity 0.71 and specificity 0.88 and with the PPV 0.94 and the NPV 0.50 (Table 3). Cognitively impaired Māori had strong diagnostic evidence with an LR+ at 5.67, whereas the LR− was at 0.33. The cutoff value for cognitive impairment in the non-Māori sample was 88 with 0.74 sensitivity and 0.78 specificity and PPV was

Table 2
Diagnostic accuracy in identifying (A) dementia and (B) cognitive impairment in Māori and non-Māori

	Māori		Non-Māori	
	Reference standard		Reference standard	
Index test	Positive	Negative	Positive	Negative
A) Dementia versus no dementia				
Positive	10	2	11	5
Negative	2	18	1	24
B) Cognitive impairment versus normal				
Positive	17	1	17	4
Negative	7	7	6	14

NOTE. Cognitive impairment is a summary variable of mild cognitive impairment and dementia.

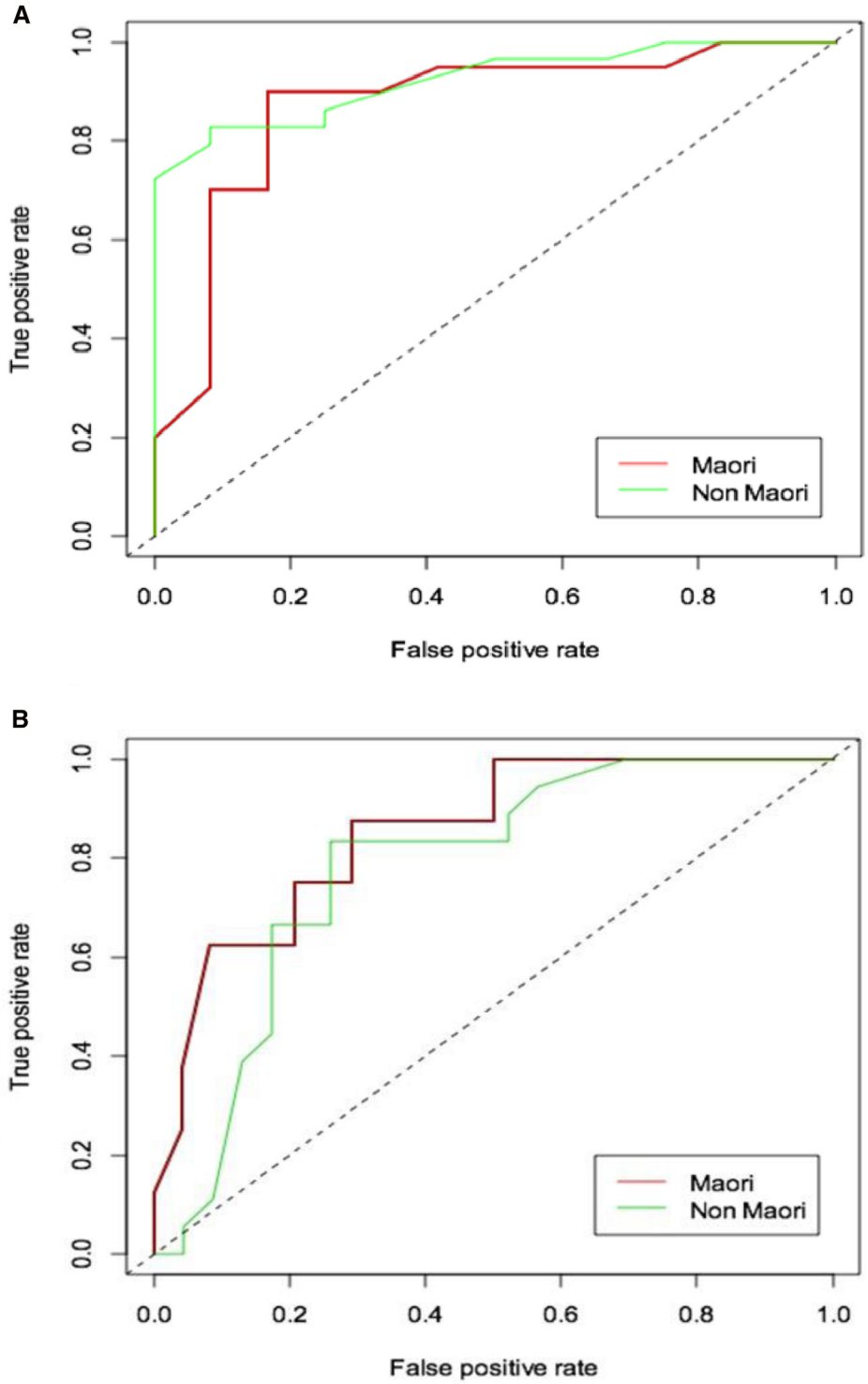

Fig. 3. (A) ROC comparing 3MS score with reference assessment for dementia for Māori and non-Māori. (B) ROC comparing 3MS score with reference assessment for cognitive impairment for Māori and non-Māori. Abbreviations: 3MS, Modified Mini–Mental State Examination; ROC, receiver operating characteristics.

0.81 and the NPV 0.70 (Table 3). LR+ and LR− were below strong diagnostic evidence for non-Māori. Agreement between the reference standard and the 3MS for identifying cognitive impairment was moderate for Māori and non-Māori (k = 0.47, 0.51, respectively).

4. Discussion

The cutoff scores differed between Māori and non-Māori octogenarians, suggesting that the 3MS has overall good discriminant validity as a global cognitive screen to distinguish dementia from nondementia (normal cognition and

Table 3
Selected cutoff values on the 3MS score for utility in identifying dementia and cognitive impairment in Māori and non-Māori

	Māori (n = 32)		Non-Māori (n = 41)	
Test characteristics	Dementia (n = 12)	Cognitive impairment (n = 24)	Dementia (n = 12)	Cognitive impairment (n = 23)
3MS cutoff value	80	85	84	88
AUC	0.87	0.84	0.9	0.77
Sensitivity (95% CI)	0.83 (0.55-0.95)	0.71 (0.51-0.85)	0.83 (0.65-0.99)	0.74 (0.54-0.87)
Specificity (95% CI)	0.90 (0.70-0.97)	0.88 (0.53-0.98)	0.80 (0.65-0.92)	0.78 (0.55-0.91)
PPV (95% CI)	0.83 (0.51-0.97)	0.94 (0.71-1.00)	0.69 (0.41-0.88)	0.81 (0.57-0.94)
NPV (95% CI)	0.90 (0.67-0.98)	0.50 (0.24-0.76)	0.96 (0.78-1.00)	0.70 (0.46-0.88)
LR+ (95% CI)	8.3 (2.18-31.79)	5.67 (0.89-36.09)	5.32 (2.35-12.02)	3.33 (1.36-8.16)
LR− (95% CI)	0.19 (0.05-0.66)	0.33 (0.17-0.66)	0.1 (0.02-0.66)	0.34 (0.16-0.70)
Diagnostic odds ratio (95% CI)	45 (5.47-370.02)	17 (1.752-164.99)	52.8 (5.50-507.27)	9.92 (2.33-42.25)

Abbreviations: 3MS, Modified Mini–Mental State Examination; AUC, area under the curve; PPV, positive predictive value; NPV, negative predictive value; LR+, positive likelihood ratio; LR−, negative likelihood ratio.

MCI combined) in Māori and non-Māori. Also, these results suggest that different cutoffs were more accurate in the two ethnic groups. However, the accuracy of discrimination between normal cognition and cognitive impairment (MCI and dementia combined) was less than ideal, indicating that more advanced stages of cognitive impairment, namely dementia, are more likely to be differentiated using the 3MS.

When used to identify dementia, the 3MS is close to the ideal sensitivity and specificity for Māori and non-Māori. Our study yielded NPVs (Māori: 0.90; non-Māori 0.96) and LR− (Māori: 0.19; non-Māori 0.10) that indicate that negative 3MS results would support excluding dementia in both Māori and non-Māori. Finally, the diagnostic odds ratio further confirms the usefulness of the 3MS for increasing the pretest probability for Māori and non-Māori.

Although varying cutoff values for the 3MS are available, a score below 78 is frequently considered to indicate cognitive impairment [17]. Our results revealed that applying the commonly used cutoff value of 77/78 would likely lead to misclassifications, greater false negatives, as our study-derived cutoff values were about 5 points greater. Our dementia cutoff values are consistent with a pragmatic study from the Cache County Study [35] that also used data-derived cutoff values, demonstrating optimal cutoff values higher than 77/78 for dementia. Using only the 3MS as the index test for the study population, with the cutoff value of 82/83, resulted in 0.92 sensitivity and 0.90 specificity [35].

The diagnostic category of cognitive impairment combined participants identified by the reference standard as having dementia or MCI, to create a heterogeneous group, potentially diluting the diagnostic accuracy of detecting cognitive impairment using the 3MS. The index test could not distinguish cognitive impairment from normal cognitive function with adequate precision. Although further research is necessary to validate the utility of the 3MS in cognitive subgroup analysis, our initial findings suggest that cutoff values are likely affected by age and ethnicity and therefore need careful consideration to ensure health equality is able to be studied.

Our findings provide a useful reference point for the NZ population, as well as potentially for advanced-age indigenous and nonindigenous populations globally. The ethnic-specific cutoff values meant that the most valid estimation of detection was applied. Our results showed that Māori had lower cutoff values than non-Māori. The reasons for this are not known but may be related to unequal access to education [36]. However, most prominently, it may be the ethnic and cultural biases in the content of the 3MS that influenced lower cutoff values for our Māori. It is probable that some of the items or practices in the index test were unfamiliar to Māori, as there was no Māori content. For example, the 3MS requires participants to memorize three nonassociated words in English, which may have different constructs in te reo Māori.

Approximately 20% of the total NZ population [37] and half of our Māori sample speak te reo Māori; thus, it is possible that English was not the first language for some Māori. It has been reported that the listening ability of monolingual and bilingual people differs, which may be attributed to the increased demand for processing and attention required of bilingual people in their second language [38]. As well, word recognition is much poorer for bilingual speakers than monolingual speakers when assessed in their second language [39]. This issue adds complexity to the accuracy of the index test for Māori. Indigenous cultures may also have different concepts of time, numbers, space, and life [40], compared with Western societies. Requesting an indigenous person to understand and complete an unfamiliar task within a specific time frame may affect their engagement and promote low motivation for execution [40], resulting in an inaccurate estimation of their cognitive function [41]. Furthermore, the cognitive assessment experience may have adversely affected Māori participants' performance on aspects of the assessment due to differences in their expectations and views of assessment environments [42]. Similar to the age cohort effect, our Māori and non-Māori may have performed differently on the cognitive assessments, not due to their cognitive capabilities but because they had different life experiences [43]. Therefore, the

3MS may not be the most suitable screening tool for cognitive function in non-European subpopulations in NZ, such as Māori.

The above points recognize the need for tino rangatiratanga (self-determination) in health research in NZ, which provides an environment for Māori to fully engage in all health research processes to ensure accuracy of data collection and interpretation from a Māori worldview. Our findings suggest that cognitive health is bound by culture and time and that accurately considering octogenarian Māori and non-Māori cognitive health requires acknowledging the heritage and culture of Māori in conducting their lives. To meet the need to incorporate a Māori worldview requires the development and validation of a culturally sensitive screening tool for cognitive function for Māori by Māori. This study shows the degree of bias between Māori and non-Māori cutoff values as at least 4 points on the 3MS. Other studies have suggested a 7-point adjustment for education [44]. Ongoing consideration of the fit of the cognitive screening test to the population evaluated will be needed.

There is currently no validated cognitive screening tool for Māori, and it was beyond the scope of this study to develop and assess one. This study provides some data on Māori, and the different cutoff values identified for Māori and non-Māori warrant consideration.

4.1. Limitations

Limitations of this study include the low number of participants and the timing of the reference standard against the index test. We have ameliorated the variability in timing of the reference standard and index test by completing sensitivity analyses that showed no difference in the utility of the index test regardless of whether the 3MS score from nearest or imputed was used.

We were unable to derive adjusted 3MS cutoff values, as age, education, and ethnicity influence the 3MS scores. Because O'connell and Tuokko [45] reported that applying age corrections for the 3MS decreased its sensitivity to detect dementia, we opted to apply no adjustments. Future studies with a larger sample may yield more precise results. Future studies should also include a wider age group as cognition assessment at all ages is important.

We acknowledge that the 3MS is currently less commonly used in NZ than other cognitive screens. It was selected as the outcome measure for cognition in LiLACS NZ because, when it began, the 3MS had the best combination of ease of use, validity, and history of use in several other longitudinal studies of aging, such as the Canadian Study of Health and Aging [46]. Considering other cognitive screens such as the Montréal Cognitive Assessment was beyond the scope of this study, future research is also needed in other cohorts with ethnic diversity to establish the reproducibility of these findings.

Our study evaluated a sample of cohort study participants who were interested in furthering their participation in research and completed the full LiLACS NZ assessment which included the 3MS, while remaining actively engaged in LiLACS NZ study. This commitment could have limited the sample and introduced selection bias toward a relatively healthier sample, as the participants who completed the full LiLACS NZ assessment were more functionally able than those who completed LiLACS NZ partial assessment. This potential limitation does not impact the validity of the diagnostic test accuracy, but it is plausible that our findings are limited in their utility and may pertain to a healthier subset of the Māori and non-Māori octogenarian population of NZ.

5. Conclusion

Given the higher prevalence of dementia in indigenous populations and in advanced age, a valid and reliable cognitive screening tool is warranted. Before our study, the 3MS had not been validated to identify dementia and cognitive impairment in Māori and non-Māori octogenarians. The 3MS demonstrated the best utility to identify dementia. Within our samples, the 3MS appears to lack validity in discriminating and detecting the milder stages of cognitive impairment and is better suited to detecting dementia. These results continue to highlight the clinical challenge of discriminating between normal cognition and mild cognitive deficits/impairment in older adults, which are not easily detected through a cognitive screening assessment [47]. Also, this study adds to the growing literature on dementia research and health services for indigenous populations [48]. Cultural limitations (e.g., the lack of Māori content) of the 3MS make it potentially inappropriate for widespread use in NZ. However, this study's evaluation is suitable for a research setting. Other culturally and educationally fair cognitive screening tools may be more appropriate for use in initial clinical evaluation of people presenting with cognitive problems. Our findings support the need to continue research to have appropriate cutoff values available for all segments of the population.

Acknowledgments

The authors wish to acknowledge the participants, their families, and whānau for supporting the study. The authors thank Te RōpuKaitiaki o ngā tikanga Māori for their guidance. The authors acknowledge the community partners in LiLACS NZ who engaged with participants and collected data (Western Bay of Plenty Primary Health Organisation, Ngā Matāpuna Oranga Kaupapa Māori Primary Health Organisation, Te Korowai Aroha Trust, Te Rūnanga o Ngati Pikiao, Rotorua Area Primary Health Services, Ngati Awa Research & Archives Trust, Te Rūnanga o Ngati Irapuaia, and Te Whanau a Apanui Community Health Centre).

K.Z. was funded by a University of Auckland Doctoral Scholarship.

The data collection for all LiLACS NZ participants was supported by the Health Research Council of New Zealand

(HRC 09/068B; UoA ref: 3624940) and Ministry of Health New Zealand (MOH ref: 345426/00; UoA ref 3703221), which funded the project management and data collection work, and Ngā Pae o te Māramatanga (UoA ref: 3624946), which funded the Māori engagement and project management.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.trci.2019.08.006.

RESEARCH IN CONTEXT

1. Systematic review: The literature was searched through medical databases focusing on the diagnostic accuracy of the Modified Mini–Mental State Examination in advanced-aged Māori and non-Māori. No studies explored its diagnostic accuracy; thus, there is a paucity of knowledge on cutoffs in advanced age and indigenous populations.
2. Interpretation: The index test demonstrated strong accuracy to detect dementia and low relative accuracy for cognitive impairment, indicating more advanced stages are more likely to be accurately diagnosed. Study-specific cutoffs are approximately 5 points greater than the commonly applied cutoff and also display ethnic variability. This research provides insight into the performance of cognitive screens in advanced age and indigenous populations.
3. Future directions: Our findings display that cutoffs in advanced age have ethnic variability. Future research should yield a larger sample and include a wider age range to generate more precise results to be able to translate this knowledge into clinical practice.

References

[1] Galasko D, Salmon D, Gamst A, Olichney J, Thal LJ, Silbert L, et al. Prevalence of dementia in Chamorros on Guam: relationship to age, gender, education, and APOE. Neurology 2007;68:1772–81.
[2] Kalaria RN, Maestre GE, Arizaga R, Friedland RP, Galasko D, Hall K, et al. Alzheimer's disease and vascular dementia in developing countries: prevalence, management, and risk factors. Lancet Neurol 2008; 7:812–26.
[3] McCracken CF, Boneham MA, Copeland JR, Williams KE, Wilson K, Scott A, et al. Prevalence of dementia and depression among elderly people in black and ethnic minorities. Br J Psychiatry 1997; 171:269–73.
[4] Rodriguez JJL, Ferri CP, Acosta D, Guerra M, Huang Y, Jacob KS, et al. Prevalence of dementia in Latin America, India, and China: a population-based cross-sectional survey. Lancet 2008;372:464–74.
[5] Warren LA, Shi Q, Young K, Borenstein A, Martiniuk A. Prevalence and incidence of dementia among indigenous populations: a systematic review. Int psychogeriatr 2015;27:1959–70.
[6] Smith K, Flicker L, Lautenschlager N, Almeida O, Atkinson D, Dwyer A, et al. High prevalence of dementia and cognitive impairment in Indigenous Australians. Neurology 2008;71:1470–3.
[7] Ogden JA, McFarlane-Nathan G. Cultural bias in the neuropsychological assessment of young Maori men. New Zealand J Psychol 1997; 26:2–12.
[8] Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, et al. Dementia prevention, intervention, and care. Lancet 2017;390:2673–734.
[9] Slavin MJ, Brodaty H, Sachdev PS. Challenges of diagnosing dementia in the oldest old population. J Gerontol A Biol Sci Med Sci 2013; 68:1103–11.
[10] Teng E, Chui H, Hubbard D, Corgiat M. The Modified Mini-Mental State (The 3MS) Test. Clin Neuropsychol 1987;1:293.
[11] Hayman KJ, Kerse N, Dyall L, Kepa M, Teh R, Wham C, et al. Life and living in advanced age: a cohort study in New Zealand–e Puawaitanga o Nga Tapuwae Kia Ora Tonu, LiLACS NZ: study protocol. BMC Geriatr 2012;12:33.
[12] Dyall L, Kepa M, Hayman K, Teh R, Moyes S, Broad JB, et al. Engagement and recruitment of Māori and non-Māori people of advanced age to LiLACS NZ. Aust N Z J Public Health 2013; 37:124–31.
[13] Statistics New Zealand. New Zealand Period Life Tables 2012 to 2014. Wellington: Statistics New Zealand; 2015.
[14] Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. BMJ 2015;351:h5527.
[15] Larner A. Diagnostic Test Accuracy Studies in Dementia: A Pragmatic Approach. London: Springer; 2015.
[16] Ransohoff DF, Feinstein AR. Problems of spectrum and bias in evaluating the efficacy of diagnostic tests. N Engl J Med 1978; 299:926–30.
[17] Tombaugh TN, McDowell I, Kristjansson B, Hubley AM. Mini-Mental State Examination (MMSE) and the modified MMSE (3Ms): a psychometric comparison and normative data. Psychol Assess 1996;8:48.
[18] Andrew MK, Rockwood K. A five-point change in Modified Mini-Mental State Examination was clinically meaningful in community-dwelling elderly people. J Clin Epidemiol 2008;61:827–31.
[19] de Craen AJM, Heeren TJ, Gussekloo J. Accuracy of the 15-item geriatric depression scale (GDS-15) in a community sample of the oldest old. Int J Geriatr Psychiatry 2003;18:63–6.
[20] Ministry of Health. Content Guide 2013/14: New Zealand Health Survey. Wellington: Ministry of Health; 2014.
[21] Teng E, Chui H. The modified mini-mental state examination (3MS). Can J Psychiatry 1987;41:114–21.
[22] Bartels C, Wegrzyn M, Wiedl A, Ackermann V, Ehrenreich H. Practice effects in healthy adults: a longitudinal study on frequent repetitive cognitive testing. BMC Neurosci 2010;11:118.
[23] Toner CK, Reese BE, Neargarder S, Riedel TM, Gilmore GC, Cronin-Golomb A. Vision-fair neuropsychological assessment in normal aging, Parkinson's disease and Alzheimer's disease. Psychol Aging 2012;27:785.
[24] Dupuis K, Pichora-Fuller MK, Chasteen AL, Marchuk V, Singh G, Smith SL. Effects of hearing and vision impairments on the Montreal Cognitive Assessment. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn 2015;22:413–37.
[25] Reischies FM, Geiselmann B. Age-related cognitive decline and vision impairment affecting the detection of dementia syndrome in old age. Br J Psychiatry 1997;171:449–51.

[26] Wittich W, Phillips N, Nasreddine ZS, Chertkow H. Sensitivity and specificity of the Montreal Cognitive Assessment modified for individuals who are visually impaired. J Vis impairment blindness 2010; 104:360.
[27] McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 1984;34:939–44.
[28] American Psychiatric Association. Diagnostic and statistic manual of mental disorders. Washington, DC: American Psychiatric Association; 1994.
[29] Noel-Storr AH, McCleery JM, Richard E, Ritchie CW, Flicker L, Cullum SJ, et al. Reporting standards for studies of diagnostic test accuracy in dementia The STARDdem Initiative. Neurology 2014; 83:364–73.
[30] Kaplan JB, Bennett T. Use of race and ethnicity in biomedical publication. JAMA 2003;289:2709–16.
[31] Larner A. The Q* index: a useful global measure of dementia screening test accuracy. Dement Geriatr Cogn Dis Extra 2015; 5:265–70.
[32] Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clin Chem 1993;39:561–77.
[33] Eusebi P. Diagnostic accuracy measures. Cerebrovasc Dis 2013; 36:267–72.
[34] Ministry of Health. Tatau Kura Tangata: Health of Older Māori Chart Book 2011. Wellington: Ministry of Health; 2011.
[35] Hayden KM, Khachaturian AS, Tschanz JT, Corcoran C, Nortond M, Breitner JC, et al. Characteristics of a two-stage screen for incident dementia. J Clin Epidemiol 2003;56: 1038–45.
[36] Murden RA, McRae TD, Kaner S, Bucknam ME. Mini-Mental State Exam Scores Vary with Education in Blacks and Whites. J Am Geriatr Soc 1991;39:149–55.
[37] Statistics New Zealand. Speakers of te reo Māori; 2017.
[38] Rogers CL, Lister JJ, Febo DM, Besing JM, Abrams HB. Effects of bilingualism, noise, and reverberation on speech perception by listeners with normal hearing. Appl Psycholinguistics 2006;27:465–85.
[39] Meador D, Flege JE, Mackay IR. Factors affecting the recognition of words in a second language. Bilingualism: Lang Cogn 2000;3:55–67.
[40] Janca A, Bullen C. The Aboriginal concept of time and its mental health implications. Australas Psychiatry 2003;11:S40–4.
[41] Fletcher-Janzen E, Strickland TL, Reynolds C. Handbook of cross-cultural neuropsychology. Springer Science & Business Media; 2013.
[42] Shepherd I, Leathem J. Factors affecting performance in cross-cultural neuropsychology: From a New Zealand bicultural perspective. J Int Neuropsychological Soc 1999;5:83–4.
[43] Williams JD, Klug MG. Aging and cognition: Methodological differences in outcome. Exp Aging Res 1996;22:219–44.
[44] Brown LM, Schinka JA, Mortimer JA, Graves AB. 3MS normative data for elderly African Americans. J Clin Exp Neuropsychol 2003; 25:234–41.
[45] O'connell ME, Tuokko H. Age corrections and dementia classification accuracy. Arch Clin Neuropsychol 2010;25:126–38.
[46] Canadian Study of Health and Aging Working Group. Canadian Study of Health and Aging: study methods and prevalence of dementia. CMAJ 1994;150:899–913.
[47] Galvin JE, Powlishta KK, Wilkins K, McKeel DW, Xiong C, Grant E, et al. Predictors of preclinical Alzheimer disease and dementia: a clinicopathologic study. Arch Neurol 2005;62:758–65.
[48] Jacklin KM, Walker JD, Shawande M. The emergence of dementia as a health concern among First Nations populations in Alberta, Canada. Can J Public Health 2013;104:e39–44.