Ophthalmic Epidemiology, 15:105–113
ISSN: 0928-6586 print / 1744-5086 online

DOI: 10.1080/09286580701840354

informa
healthcare

Assessing Participation in Daily Living and the Effectiveness of Rehabiliation in Age Related Macular Degeneration Patients Using the Impact of Vision Impairment Scale

Ecosse L. Lamoureux,[1,2] Julie F. Pallant,[3] Konrad Pesudovs,[4] Alan Tennant,[5] Gwyn Rees,[1] Patricia M. O'Connor,[1,2] and Jill E. Keeffe[1,2]

[1] *Centre for Eye Research Australia-The University of Melbourne, Australia*
[2] *Vision CRC-Sydney, Australia*
[3] *School of Rural Health-University of Melbourne, Australia*
[4] *NH&MRC Centre for Clinical Eye Research-Flinders University and Flinders Medical Centre, Australia*
[5] *Department of Rehabilitation Medicine, Faculty of Medicine and Health, University of Leeds, United Kingdom*

ABSTRACT

Purpose: **To assess if the Impact of Vision Impairment (IVI) is a valid instrument to measure participation in daily activities and rehabilitation in patients with age-related macular degeneration (AMD) and varying levels of visual impairment.** ***Methods:*** **Participants, recruited from a public eye hospital and low vision centers, completed the IVI questionnaire. The IVI and its three subscales were assessed for fit to the Rasch model. Unidimensionality, item fit, response category performance, and targeting of items to patients were assessed. Confirmatory factor analysis (CFA) was used to assess the three-factor model of the IVI in this sample of AMD patients.** ***Results:*** **219 patients (mean $\pm$ SD age $=$ 83.5 $\pm$ 7.4 yr) were recruited. Of these, 22%, 55% and 23% had mild ($<$6/12–6/18), moderate ($<$6/18–6/60) and severe ($<$6/60) vision loss, respectively. The IVI total and three subscales displayed discrete thresholds indicating that the respondents understood the response categories. The IVI items fitted the scale and unidimensionality was established. Person separation reliability for the IVI score was substantial (0.94) indicating that the scale can discriminate between several groups of AMD patients. The IVI items were significantly targeted to the AMD patients with the means of the two distributions shown to be very close (0.0 and 0.1, respectively). Substantial targeting was also evident for the subscales. Poorer visual acuity was significantly associated (ANOVA; $F(2, 216) = 23.4$; $p < 0.001$) with greater restriction of participation suggesting that the IVI has substantial construct validity. CFA supported the IVI three-factor model which includes items from the "emotional well-being, "reading and accessing information" and "mobility and independence" subscales.** ***Conclusions:*** **Clinicians and researchers can reliably use the IVI to assess the impact on daily life and the effectiveness of clinical trials and rehabilitation interventions in patients with AMD across a range of vision loss.**

INTRODUCTION

The most recent World Health Organization (WHO) data on vision impairment conservatively estimates that 14 million persons are blind or visually impaired as a result of Age Related Macular Degeneration (AMD).[1] In Australia, the prevalence of blindness in AMD patients older than 85 years has been reported to be 18.5%.[2] People with AMD usually retain their peripheral vision but lose their central vision which in turn, impacts on daily living that requires fine vision such as reading and watching TV.[3] AMD-related vision impairment has also been associated with depression, poor mental health and reduced quality of life.[4–6] An ageing population means that the number of people with AMD is likely to increase and a further understanding of the impact of this eye condition on participation in daily living is needed and should be included as an outcome measure in rehabilitation and clinical trials. To facilitate this, an appropriate instrument is required.

Received 8 June 2007, Accepted 2 October 2007
Keywords: AMD; participation in daily living; quality of life; Rasch analysis.
Correspondence to:
Ecosse Lamoureux, Centre for Eye Research Australia, Department of Ophthalmology University of Melbourne, 32 Gisborne St, East Melbourne, Victoria, 3002, Australia.
e-mail: ecosse@unimelb.edu.au

While a number of self-reported questionnaires have been used to assess the impact of AMD,[7–11] no vision-specific assessment of quality of life in people with AMD has been performed using a Rasch-scaled measure. A Rasch-calibrated instrument estimates linear interval measures from ordinal raw scores facilitating the use of parametric statistical techniques. This improves the accuracy of scoring and removes measurement noise which in turn improves sensitivity to intervention-induced changes and correlations with other variables.[12–15] Rasch analysis also assesses the instrument's validity, particularly if the scale items target the spectrum of the overall trait being measured i.e. participation in daily life or visual disability.[16] It therefore provides a valuable means to assess the characteristics of an instrument designed to measure participation in daily living or quality of life.

In assessing the impact of vision impairment and the effectiveness of intervention trials, it would be beneficial to have a valid vision- and disease-specific instrument. Previously, we demonstrated that the Impact of Visual Impairment instrument (IVI) was a valid scale to assess participation and the effectiveness of rehabilitation in vision impaired people.[17,18] We also showed that the IVI was a sensitive measure to assess the impact of cataract surgery on specific areas of daily functioning in patients with early AMD. [19] To effectively assess the impact of rehabilitation and clinical trials in patients with AMD, it is critical to have a scale that does not use summative scoring as this technique assumes erroneously that the overall trait being measured have interval measurement characteristics and that each item represents equal difficulty, and scores them equally.[14]

Rather, an appropriate scale needs to possess demonstrated measurement features (accuracy, sensitivity, reliability and validity) usually confirmed when the scale data fit the Rasch model. The original IVI was validated with almost a quarter of its sample diagnosed with AMD, so it seems likely that the IVI would be suitable for AMD subjects.[20] However, this has not been specifically shown, and since three-quarters of this original validation population did not have AMD, the validity of the IVI for this sub-population cannot be assumed. The aim of this study was therefore to empirically determine if the IVI provides a valid assessment of perceived restriction of participation in AMD patients with a range of visual impairment.

Participants

Participants (N = 219) were recruited from tertiary public eye clinics at the Royal Victorian Eye and Ear Hospital (RVEEH) and low vision rehabilitation centers across Victoria, Australia. The eligibility criteria for the study included presenting visual acuity < 6/12, ≥18 years of age, a diagnosis of AMD as the main cause of vision impairment, and the ability to converse in English. Potentially eligible participants who agreed to participate completed a consent form that allowed access to their hospital or agency histories. The IVI, sociodemographic and clinical data were collected. Ethical approval was obtained from the RVEEH Human Research and Ethics Committee. This research adhered to the tenets of the Declaration of Helsinki.

The IVI was developed to assess the restriction of participation in daily activities in people with low vision. It can be self- or interviewer-administered. Recently, the IVI was further validated to examine its response scale and internal consistency as well as to provide the true linear scoring benefits of Rasch analysis.[17] This resulted in a 28-item questionnaire with a 4-category response scale for 26 items-*"not at all"* (0), *"a little"* (1), *"a fair amount"* (2), *"a lot"* (3) and a 3-category response scale for 2 items-*"not at all"* (0), *"a fair amount"* (1), *"a lot"* (2). [17] A 3-subscale structure possessing interval level measurement characteristics was subsequently confirmed using Confirmatory Factor and Rasch analyses. [21] They are "Emotional well being," "Reading and accessing information" and "Mobility and independence." The revised 28-item IVI was used in this study, and scored for an total score and 3 subscale scores.[17]

Rasch analysis

The IVI data were fitted to the Rasch model [22] using the RUMM2020 software.[23] The Rasch model assumes that the probability of a patient selecting a response category for any item is a logistic function of the relative distance between the item level of difficulty and patient's level of ability. Consequently, it is anticipated that the probability of endorsing a particular rating category will increase monotonically with the difference between the person's level of difficulty in performing daily activities and the level of difficulty required for the task. Where the scale data meet the Rasch model expectations, the ordinal raw score is transformed into an interval scale.[24,25] Among a number of advantages, normally distributed interval-level measurement allows for the use of parametric analysis of data. This is particularly important as the misuse of ordinal scores can compromise the results of clinical trial analyses when these scores are used to calculate changes across experimental and control groups.[25]

Three overall fit statistics are considered. An item-trait interaction score reported as a Chi-Square (χ^2), which reflects the property of invariance across the trait. An item-trait interaction probability value >0.002 (Bonferroni-adjusted p value) was used to indicate no substantial deviation from the Rasch model. Two other Fit statistics represent the residuals between the expected estimate and actual values for each person-item, summed over all items for each person and over all persons for each item. The residuals are transformed to approximate a z-score and represent a standardized normal distribution where perfect fit to the model would have a mean of approximately 0 and a standard deviation of 1.

A person separation reliability score ranging between 0 and 1 indicates how well the items of the instrument separate the respondents. Larger values indicate a greater ability to distinguish between strata of person ability. A value of 0.9, for example, represents an ability to distinguish four strata of person ability. Individual item or person statistics with Fit Residuals values >2.5 or probability values below the Bonferroni adjusted alpha value were used to indicate misfit of the data to the model. Item removal was also considered if items demonstrated Fit residual values >2.5 or less than Bonferroni-adjusted probability scores ($p = 0.002$).

The ordering of thresholds (i.e. how the patents interpret the transition between categories) was investigated. Disordered thresholds is a sign that the categories are not working as intended and can occur when there are too many response options, or when the labeling of options is similar to each other, potentially confusing or open to misinterpretation. The collapsing of adjacent categories was considered in the event of disordered thresholds.

Similarly, the occurrence of differential item functioning (DIF) was statistically tested to ascertain if subgroups within the sample (e.g. gender), despite equal levels of the underlying trait, responded differently to an individual item. Targeting was also assessed as it was important to determine if the IVI items were particularly suitable to assess participation in visual disability associated with AMD. Poorly targeted measures are limited by floor or ceiling effects, display an uneven spread of items across the full range of respondent's scores and show insufficient items to assess the full range of the sample trait.

Unidimensionality provides further evidence that the instrument is measuring the underlying trait (participation in daily living) that it purports to measure. The unidimensionality of the IVI was assessed using Principal Components Analysis (PCA) of the residuals. Unidimensionality is formally tested in RUMM2020 by allowing the pattern of factor loadings on the first component to determine "subsets" of items ("positive" and "negative" loadings subsets). If person estimates derived from these two subsets of items statistically differ (using independent t-test provided in RUMM) from the estimates derived from the full scale, a breach of the assumption of unidimensionality is indicated. [26]

Confirmatory factor analysis

Confirmatory factor analysis (CFA) using AMOS (Version 6, SPSS Science, Chicago, Illinois, USA) was used to confirm the three-subscale structure of the IVI as found previously.[21] The three-factor model comprised three latent traits namely mobility and independence (11 items), emotional well-being (8 items) and reading and access to information (9 items). CFA using maximum likelihood estimation was conducted on the calibrated person-item scores to evaluate fit of each proposed model. Winsteps version 3.61[27] was used to generate calibrated person-item scores as this feature is not available in RUMM and has been described previously.[21]

A good model fit can be indicated by a non-significant item-trait interaction χ^2 probability value. However, because the χ^2 test has been criticized for its dependence on sample size, a range of fit statistics were assessed. A relative χ^2 is usually used (ratio of χ^2 to degrees of freedom- χ^2/d.f.) with a recommended range of 1.0–2.0.[28] The Root Mean-Square Error of Approximation (RMSEA) is the one of the most informative statistics in determining model fit as it takes into account the number of variables that are estimated in the model.[29−31] RMSEA values are required to be ≤ 0.05 to indicate good fit. Values between 0.05 and 0.08 indicate reasonable fit.[29−31] For the incremental fit statistics (Goodness of Fit Index: GFI; the Tucker-Lewis Index: TLI; and the Comparative Fit index: CFI) values <0.90 indicate lack of fit, values between 0.90 and 0.95 indicate reasonable fit and values between 0.95 and 1.00 indicate good fit.[29−31]

Table 1. The characteristics of the 219 study participants.

Age (yr)	Mean ± SD	82.8 ±7.4
	Range	63–103
Gender	Men	74 (34%)
	Women	145 (66%)
Presenting visual acuity	<6/12–6/18 (<20/40–20/60)	48 (22%)
	<6/18–6/60 (<20/60-20/200)	122 (55%)
	<6/60 (<20/200)	49 (23%)
Duration of vision impairment (yr)	Median (min, max)	3 (0.1, 54)
Comorbidity	Yes	167 (76%)
	No	42 (19%)[a]
Comorbidity affects daily living?	Not at all	43 (25%)
	A little	60 (36%)
	A great deal	64 (38%)[b]

a and b: data from 9 and 1 participants are missing.

RESULTS

The patients' (N = 219) demographics and clinical data are shown in Table 1. 66% were female and 78% had moderate to severe visual impairment (<6/18).

Fit of the IVI data to the Rasch model

For ease of interpretation, the IVI scores were reversed for Rasch analysis giving participants with higher levels of participation higher scores. The partial credit approach..[32] (which allows each item to have its own threshold parameters), was used because the likelihood-ratio test in RUMM 2020 was statistically significant ($p < 0.001$) indicating that the rating scale model (which requires equivalent thresholds across all items) was not appropriate.

Rasch analysis of the total score showed fit to the Rasch model with a non significant (Bonferroni adjusted) Item-Trait Interaction probability value (χ^2 (df) = 80.4 (56); $p = 0.02$). This is an important finding as it demonstrates that IVI data fit the expectations of the measurement model. There was no evidence of disordered thresholds (Figure 1) suggesting that the response options of the IVI are discreet and that AMD patients could reliably discriminate between the categories of difficulty of the scale. The three IVI subscales "*Emotional well being*", "*Reading and accessing information*" and "*Mobility and independence*" when fitted to the Rasch model, also recorded non-significant probability values indicating no misfit between data and model ($p = 0.62$, 0.13 and 0.21, respectively). In addition, all items recorded ordered thresholds for the three subscales.

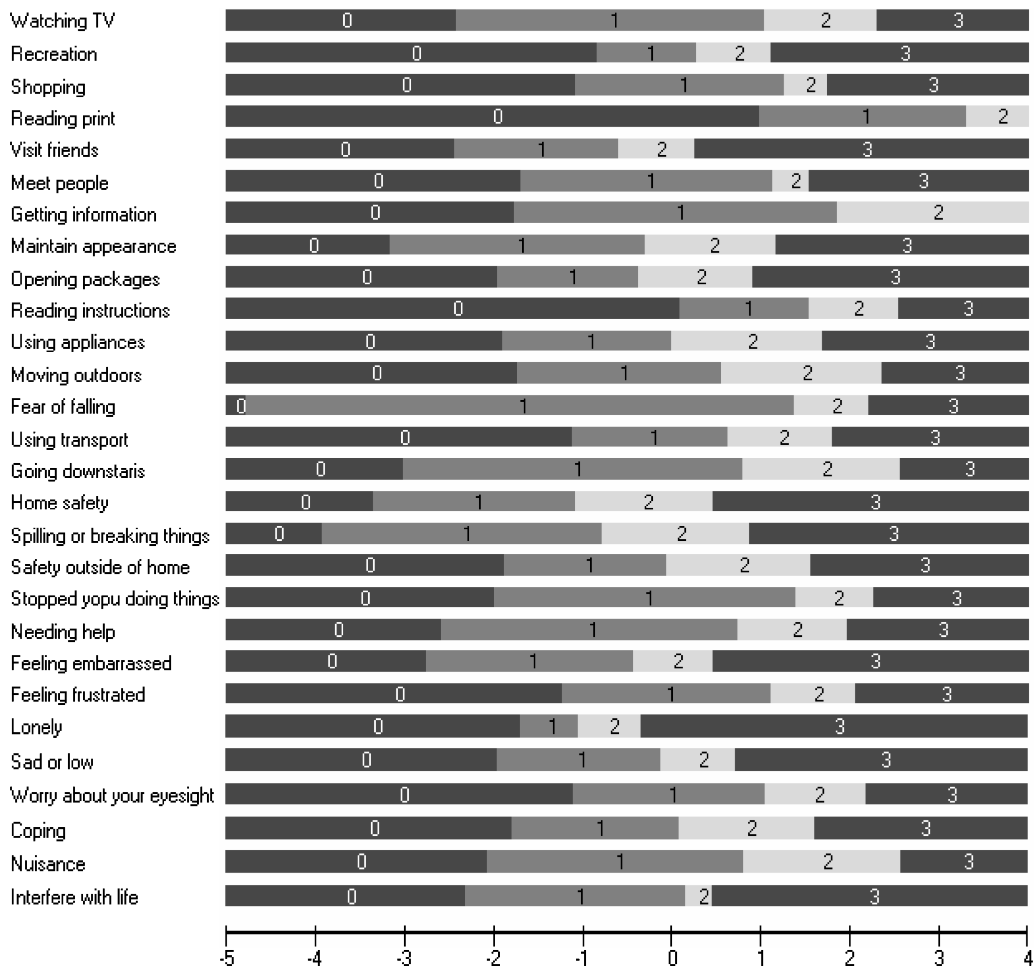

Figure 1. Threshold map of the IVI showing 'ordered thresholds' which indicates that the participants could reliably discriminate between the categories of difficulty of the IVI.

Estimates of item measure

For the total score, the use of the rating scale categories was approximately normally distributed, with the middle categories "A little" and "A fair amount" representing 27% to 39% of the ratings and the extreme categories "Not at all" and "A lot" representing 15% to 19% of the ratings, respectively (Table 2). At the item level, this pattern was evident for a number of items such as *"operating household appliances;" "fear of falling or tripping;" "going down step;" "safety outside of home"*; and *"feeling sad or low"*. Item-by-item analysis of each rating scale category showed that 86.4% of the rating scale categories (95/110) had more than 10 observations. Similar findings were found for the three subscales.

Examination of the individual items in the total IVI showed no misfit to model expectation with a mean = 0.07, SD = 0.94 (optimal values are 0 and 1, respectively) with Fit Residual values ranging between −1.78 to 2.34 (Table 2). Similar results were found for "E*motional well being*" (mean = 0.06, SD = 1.15), "R*eading and accessing information*" (mean = −0.06, SD = 0.97) and "M*obility and independence*" (mean = 0.09, SD = 0.78) subscales. All items showed Fit Residuals values <2.5 with Bonferroni adjusted probability. For the total score, our estimates of item measures in this AMD population were almost identical to those found in a low vision participants (r = 0.99).[17] but substantially different in glaucoma patients (r = 0.19).[33]

Person separation reliability

The person separation reliability score for the total IVI was 0.94 and ranged between 0.90 and 0.92 for the three subscales. This finding indicates that the scale can discriminate between groups of respondents with 4 or more different levels of restriction of participation in daily living.

Differential item functioning

Gender, degree of visual impairment, duration of visual impairment, comorbidity and effect of comorbidity on daily living were assessed for the total and subscale scores and were found to be free from DIF, with probability values exceeding the adjusted alpha value for each of the factors assessed. This finding

Table 2. Category response proportions (categories reversed) and Fit indices of the 28 IVI items to the Rasch model for the total score (location, standard error, fit residuals, chi-Square and probability values).

IVI Items	Category response proportions (%) 1	2	3	4	Location	SE	FitResid	χ^2	Prob
See and enjoy TV	11	55	26	9	0.31	0.11	0.86	5.49	0.06
Recreational activities	25	30	25	20	0.18	0.11	2.34	2.82	0.24
Shopping	25	44	18	13	0.65	0.10	−1.06	0.68	0.71
Reading print	64	32	4	—	2.14	0.14	0.37	2.62	0.27
Visiting friends	6	23	30	40	−0.93	0.10	−0.49	0.94	0.62
Recognising people	17	48	20	15	0.32	0.10	−0.04	0.20	0.91
Getting information	17	63	19	—	0.04	0.14	0.73	2.24	0.33
Looking after appearance	5	34	37	25	−0.77	0.10	0.18	1.38	0.50
Opening packaging	10	28	34	28	−0.47	0.10	0.13	4.60	0.10
Reading labels	43	36	15	6	1.39	0.10	1.18	1.93	0.38
Operating appliances	12	36	33	19	−0.07	0.10	−0.67	9.22	0.01
Getting about outdoors	16	43	29	12	0.40	0.11	−0.70	1.15	0.56
Fear of falling or tripping	2	68	21	9	−0.40	0.13	0.96	0.21	0.90
Travelling or using transport	24	38	24	14	0.43	0.11	−0.42	2.37	0.31
Going down steps	7	54	30	9	0.12	0.12	0.12	0.53	0.77
Safety at home	3	21	37	38	−1.33	0.11	−0.28	2.32	0.31
Spilling things	3	27	39	31	−1.28	0.11	−1.18	3.81	0.15
Safety outside of home	13	33	34	20	−0.13	0.10	0.35	2.73	0.26
Stopped you doing things	15	56	19	10	0.55	0.11	−1.15	3.59	0.17
Need help	9	50	27	14	0.04	0.11	−0.64	4.94	0.08
Embarrassed	6	28	31	35	−0.91	0.10	0.30	2.86	0.24
Frustrated	23	44	22	11	0.65	0.10	−0.39	6.38	0.04
Lonely	7	16	28	49	−1.03	0.10	0.67	4.96	0.08
Sad or low	11	30	30	29	−0.45	0.10	0.62	1.05	0.59
Worry about your eyesight	23	45	24	9	0.72	0.10	1.85	3.81	0.15
Coping	13	35	33	19	−0.03	0.10	−0.29	0.47	0.79
Nuisance	14	48	28	10	0.45	0.11	−1.78	6.12	0.05
Interfere with life	9	34	25	32	−0.56	0.10	0.28	1.01	0.60

SE = Standard Error, FitResid = Fit Residuals, χ^2 =Chi-Square and Prob = probability score.
*All items showed Fit Residuals values <2.5 and Bonferroni adjusted probability scores >0.002 (0.05/28).

indicates that the IVI performs with similar accuracy regardless of subgroups within these person factors.

Targeting

The participants' range of ability (−5.49 to 4.81 logits) for the total score was found to have a normal distribution (Kolmogorov-Smirnov Z test score = 0.72; p = 0.68). The person-item threshold map (Figure 2) shows the person and item thresholds on the same calibrated scale (upper and lower sections of the graph, respectively). The map shows an even spread of items across the full range of respondents' scores suggesting effective targeting of the AMD patients (top) to the IVI items and thresholds (bottom).

The mean person location logit value (0.13) substantiates that overall the questionnaire was well-targeted and that the participants had a marginally higher level of ability than the average of the scale items (which would be 0 logit). Targetting was also similarly effective for the three subscales with mean person location values of 0.31, 0.30 and −0.32 logits for the *"Emotional well being,"* "*Reading and accessing information*" and "*Mobility and independence*" subscales, respectively. In addition, inspection of the targeting maps (Figures 3A–C revealed a consistent spread of items across the range of the participants' scores when grouped under mild, moderate and severe levels of vision impairment. This result indicates the IVI items suitably target AMD patients across the spectrum of visual impairment.

Overall, the five most difficult items in the IVI were "*reading ordinary size print*;" "*reading labels or instructions on medicine*;" "*feeling frustrated or annoyed*;" "*worried about your eyesight getting worse*;" and "*shopping*" with logit scores of 2.1, 1.4, 0.7, 0.7 and 0.6, respectively (Table 2). Conversely, the five least difficult items were "*general safety at home*;" "*spilling or breaking things*;" "*feeling lonely and isolated*;" "*visiting friends or family*;" and "*feeling embarrassed*" with logit scores of −1.3, −1.3, −1.0, −0.9 and −0.9, respectively (Table 2). Targetting was also similarly effective for the three subscales with mean person location values of 0.3, 0.3 and -0.3 logits for the "Emotional well being," "Reading and accessing information" and "Mobility and independence" subscales, respectively.

Unidimensionality

The presence of unidimensionality is the most important base in interpreting results from item response analysis and was assessed using established procedures.[26,34] Principal Components Analysis of the residuals identified two subsets of items for the total IVI consisting of the highest "positive loadings" and

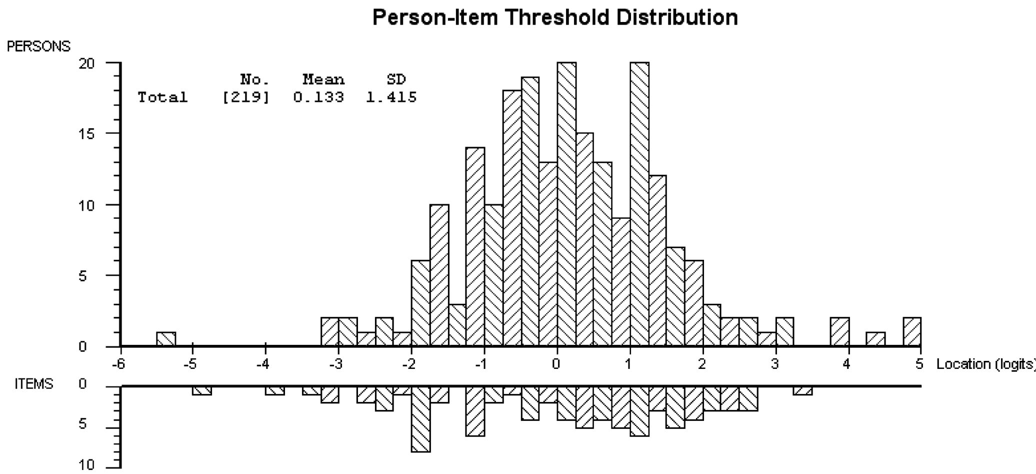

Figure 2. The targeting map showing an even spread of items across the full range of the respondents' scores suggesting effective targeting of the Age Related Macular Degeneration participants (upper half) to the Impact of Vision Impairment items and thresholds (lower half).

"negative loading" items. Person estimates generated for the subsets in each case were subjected to a series of independent t-tests to compare the estimates for each person. For the total score, the negative subset (PC loadings <0.3) represented three items namely "Safety at home;" "Safety outside of home;" and "Shopping". The positive subset (PC loadings >0.3) comprised three items which included "Feel frustrated;" "Feel lonely;" and "Feel sad or low". Similar subsets were also produced for the three subscales. Less than 5% of the estimates were found to be significantly different and therefore no evidence of multidimensionality was detected for the total and three subscales scores of the IVI.

Validity

The construct validity of the Rasch-calibrated total score IVI was tested by assessing its ability to discriminate between participants of different levels of visual impairment, namely mild (<6/12 to 6/18), moderate (<6/18 to 6/60) and severe (<6/60). Poorer visual acuity was significantly associated (ANOVA; $F\,(2, 216) = 23.4$; $p < 0.001$) with greater restriction of participation (1.06, 0.11 and −0.73, mean logit values for mild, moderate and severe visual impairment, respectively). Similar findings were found for the three subscales (Table 3).

Table 3. Person measures for those with mild, moderate and severe visual impairment on the IVI total and three subscales scores.

	Level of visual impairment				
	Mild	Moderate	Severe	ANOVA results	
IVI scores	(n = 48)	(n = 122)	(n = 49)	F	p
Emotion subscale	1.28	0.30	−0.52	12.164	<0.001*
Mobility subscale	1.35	0.34	−0.61	17.819	<0.001*
Reading subscale	0.76	0.26	−1.46	25.275	<0.001*
Total score	1.06	0.11	−0.73	23.357	<0.001*

*Post hoc comparisons showed significant differences ($p < 0.05$) between person measures (in logit) when comparing mild vs. moderate; moderate vs. severe; and mild vs. severe levels of visual impairment.

Confirmatory factor analysis

The goodness of fit statistics for the 3-factor model are shown in Table 4. All the indices showed a reasonable fit between the IVI data and the 3-factor model. The beta coefficients of all items were all statistically significant ($p < 0.001$) and ranged between 0.56–0.73, 0.65–0.80 and 0.55–0.78 for the mobility and independence; emotional well-being; and reading and accessing information subscales, respectively. These findings provide the evidence of the 3-subscale structure of the IVI as previously demonstrated with a low vision population.[21]

DISCUSSION

We set out to determine if the IVI, initially validated with a population of people with low vision, was equally a suitable measure of participation in daily activities in AMD patients with a range of visual impairment. Our findings indicated that the 28-item IVI satisfies the standards of measurement described by the Rasch model when used in a sample of AMD patients.

Table 4. Goodness of fit statistics for the 3-Factor model.

Fit indices	Recommended values	Values
χ^2	N/A	562.9
d.f.	N/A	335
χ^2/d.f.	≤ 2.00	1.68
Root mean square error of approximation	≤ 0.08	0.056
Goodness of fit index	≥ 0.9	0.875
Comparative fit index	≥ 0.9	0.932
Tucker-Lewis Index	≥ 0.9	0.923

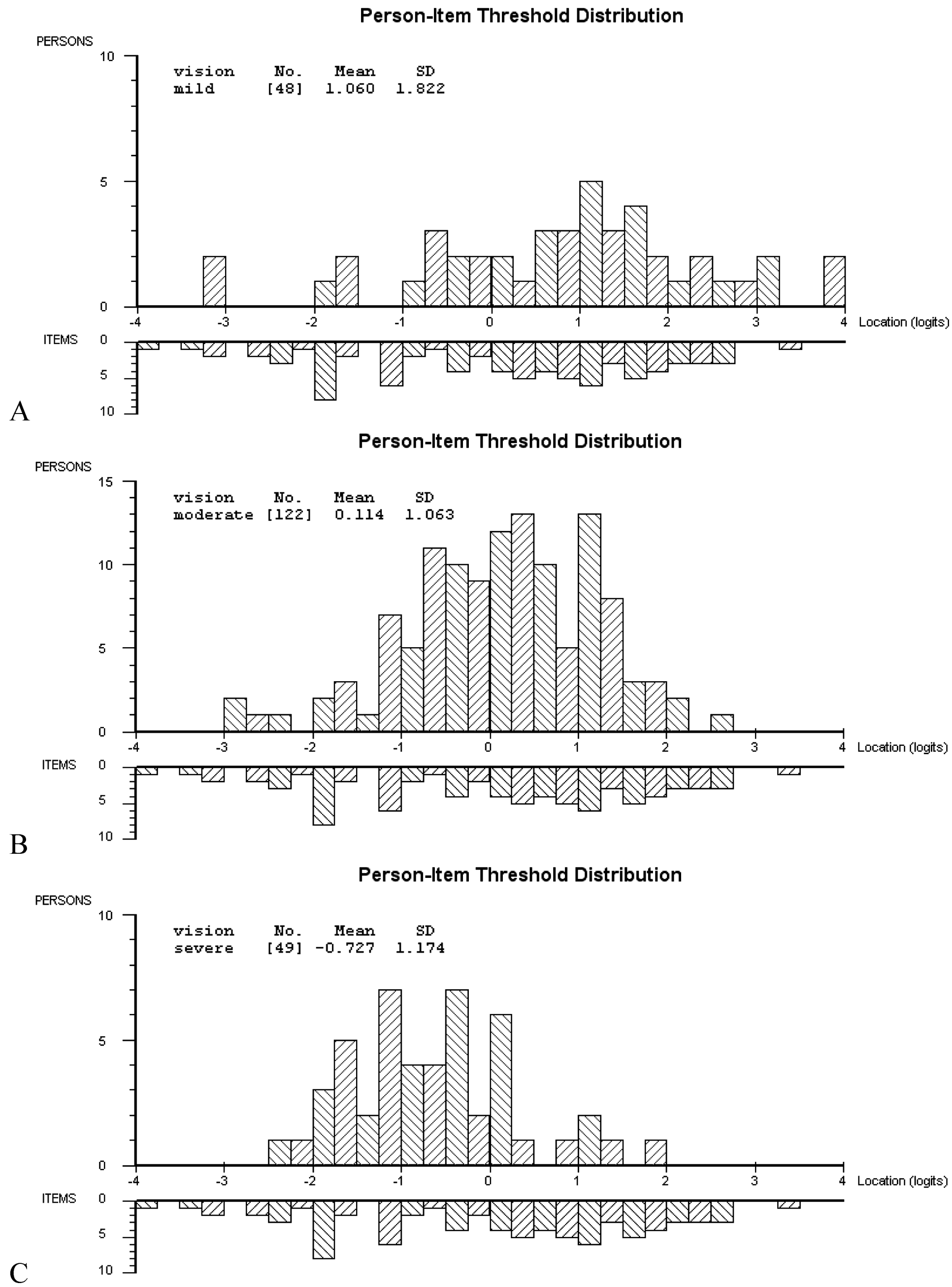

Figure 3. (A-C). The targeting maps showing an even spread of items across the range of the respondents with mild (A), moderate (B) and severe (C) vision impairment suggesting effective targeting of the Age Related Macular Degeneration participants (upper half) to the Impact of Vision Impairment items and thresholds (lower half) across the range vision loss.

Ordered thresholds were consistent across all items and the estimates of item and person measures showed no misfit to the model expectation. In addition, there was no evidence of multidimensionality or differential item functioning. We also found appropriate targeting of items to AMD patients not only as a group but also when categorized as mild, moderate and severe vision impairment.

Confirmatory factor analysis substantiated the 3-subscale structure of the IVI representing items from the emotional well-being, reading and accessing information and mobility and independence. Substantial construct validity was also found for the total and three subscale scores. These findings collectively demonstrate that the IVI, with its three subscales, is a valid scale to measure self-reported restriction of participation in daily activities in AMD patients with varying levels of visual impairment.

We recently also investigated if the IVI was suitable to assess participation in patients with glaucoma, but with relatively

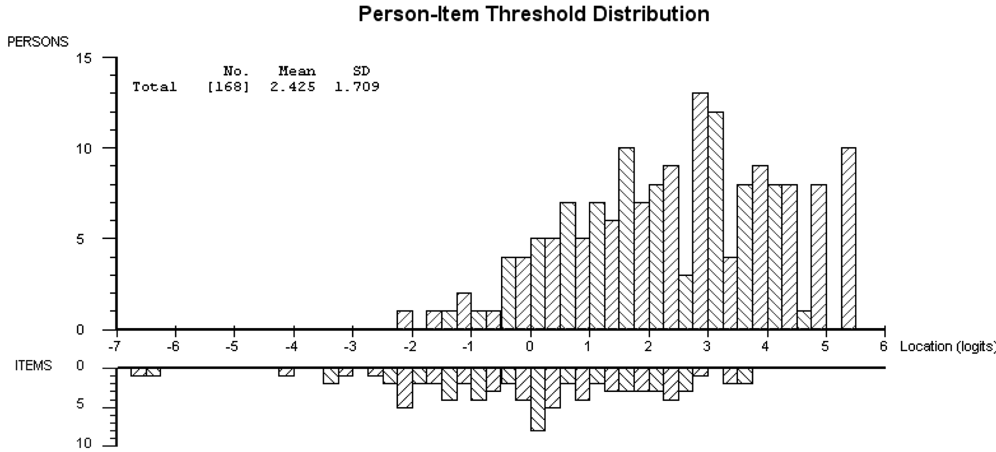

Figure 4. The targeting map showing a skewed distribution of items across the range of the respondents' scores suggesting a less than optimal targeting of the glaucoma participants (upper half) to the IVI items and thresholds (lower half).

good vision.[33] A skewed targeting was evident in that study as a large number (90%) of the patients had relatively little or no difficulty with the most difficult item being of relatively good vision (Figure 4). As opposed to that, we found substantial targeting in this study as our AMD participants displayed a range of visual impairment. The discrepancy between these two studies could be related to the spectrum of visual impairment in the two populations rather than differences in eye conditions.

Interestingly, although we recorded appropriate targeting when our AMD participants were categorized according to their level of visual impairment, there was some evidence of clustering of participants to the right of the graph (i.e., more have positive scores) for the mild group (Figure 3A) and to the left of the graph (i.e. more have negative scores) for the severe group (Figure 3C). This finding is, however, not unusual and in fact anticipated as participants with mild vision loss would be expected to have a ability higher to participate in most daily living activities and therefore have positive scores. Conversely, participants with severely compromised vision are likely to have negative scores as their ability to participate is less than the required visual ability of the scale items. The IVI could be used as a valuable tool to monitor changes in AMD participants with a range of visual impairment in how they move along the horizontal axis of the target map subsequent to rehabilitation and treatment trials to improve vision.

The impact of AMD on quality of life has previously been shown to be associated with reading, watching television, driving, and emotional well being.[3,35,36] Although not commonly acknowledged, deterioration in visual functioning in patients with AMD have also been associated with poor performances in mobility measures.[37] Our findings indicate that mobility and independence-related activities are specific areas of concern for this population with one item (going shopping) rated among the most difficult activities. Considering the impact of impaired mobility and poor vision on falls and institutionalization,[38] the IVI and in particular the items under the "mobility and independence" subscale can provide an appropriate assessment of the magnitude of restriction in mobility-related activities.

In conclusion, AMD has a tremendous impact on the physical and mental health of the geriatric population and their families and is emerging as a major public health burden especially in developed countries. A valid and appropriate instrument to assess the impact of this eye condition across the spectrum of visual impairment is therefore critical. Clinicians and researchers can reliably use the IVI to assess restriction of participation in daily living activities in patents with AMD. This also makes the IVI, which also comprises three subscales (*"Mobility and independence," "Emotional well being"* and *"Reading and accessing information"*), an ideal instrument for use in determining specific outcomes of clinical trials and rehabilitation programs.

Lately, the inhibition of vascular endothelial growth factor (VEGF) has been shown to be an effective strategy for the treatment of neovascular AMD and has produced significant improvements in vision among treatment groups.[39–42] Future studies could also assess the impact of the anti-VEGF treatments on overall and specific areas of daily living using the IVI.

REFERENCES

1. Gehrs KM, Anderson DH, Johnson LV, Hageman GS. Age-related macular degeneration-emerging pathogenetic and therapeutic concepts. *Ann Med*. 2006;38:450–71.
2. O'Shea JG. Age-related macular degeneration: A leading cause of blindness. *Med J Aust*. 1996;165:561–4.
3. Hassell JB, Lamoureux EL, Keeffe JE. Impact of age related macular degeneration on quality of life. *Br J Ophthalmol*. 2006;90:593–6.
4. Williams RA, Brody BL, Thomas RG, Kaplan RM, Brown SI. The psychosocial impact of macular degeneration. *Arch Ophthalmol*. 1998;116:514–20.
5. Mitchell J, Bradley P, Anderson SJ, Ffytche T, Bradley C. Perceived quality of health care in macular disease: a survey of members of the Macular Disease Society. *Br J Ophthalmol*. 2002;86:777–81.

6. Rovner BW, Casten RJ, Tasman WS. Effect of depression on vision function in age-related macular degeneration. *Arch Ophthalmol*. 2002;120:1041–4.
7. Frost NA, Sparrow JM, Durant JS, Donovan JL, Peters TJ, Brookes ST. Development of a questionnaire for measurement of vision-related quality of life. *Ophthalmic Epidemiol*. 1998;5:185–210.
8. Steinberg EP, Tielsch JM, Schein OD, Javitt JC, Sharkey P, Cassard SD, Legro MW, Diener-West M, Bass EB, Damiano AM, et al. The VF–14. An index of functional impairment in patients with cataract. *Arch Ophthalmol*. 1994;112:630–8.
9. Mangione CM, Lee PP, Gutierrez PR, Spritzer K, Berry S, Hays RD. Development of the 25-item National Eye Institute Visual Function Questionnaire. *Arch Ophthalmol*. 2001;119:1050–8.
10. Hart PM, Chakravarthy U, Stevenson MR, Jamison JQ. A vision specific functional index for use in patients with age related macular degeneration. *Br J Ophthalmol*. 1999;83:1115–20.
11. Mitchell J, Wolffsohn JS, Woodcock A, Anderson SJ, McMillan CV, Ffytche T, Rubinstein M, Amoaku W, Bradley C. Psychometric evaluation of the MacDQoL individualised measure of the impact of macular degeneration on quality of life. *Health Qual Life Outcomes*. 2005;3:25.
12. Norquist JM, Fitzpatrick R, Dawson J, Jenkinson C. Comparing alternative Rasch-based methods vs raw scores in measuring change in health. *Med Care*. 2004;42:I25–36.
13. Garamendi E, Pesudovs K, Stevens MJ, Elliott DB. The Refractive Status and Vision Profile: Evaluation of psychometric properties and comparison of Rasch and summated Likert-scaling. *Vision Res*. 2006;46:1375–1383.
14. Pesudovs K. Patient-centred measurement in ophthalmology - A paradigm shift. *BMC Ophthalmol*. 2006;6:25.
15. Pesudovs K, Garamendi E, Elliott DB. The Quality of Life Impact of Refractive Correction (QIRC) Questionnaire: Development and validation. *Optom Vis Sci*. 2004;81:769–777.
16. Pesudovs K, Garamendi E, Keeves JP, Elliott DB. The Activities of Daily Vision Scale for cataract surgery outcomes: re-evaluating validity with Rasch analysis. *Invest Ophthalmol Vis Sci*. 2003;44:2892–2899.
17. Lamoureux E, Pallant J, Pesudovs K, Hassell J, Keeffe J. The Impact of Vision Impairment Questionnaire: An evaluation of its measurement properties using Rasch analysis. *Invest Ophthalmol Vis Sci*. 2006;47:4732–4741.
18. Lamoureux EL, Pallant JF, Pesudovs K, Rees G, Hassell JB, Keeffe JE. The effectiveness of low-vision rehabilitation on participation in daily living and quality of life. *Invest Ophthalmol Vis Sci*. 2007;48:1476–82.
19. Lamoureux E, Hooper C, Lim L, Pallant J, Hunt N, Keeffe J, Guymer R. Impact of cataract surgery on quality of life in patients with early age-related macular degeneration. *Optom Vis Sci*. 2007;84: 683–688.
20. Weih LM, Hassell JB, Keeffe JE. Assessment of the impact of vision impairment. *Invest Ophthalmol Vis Sci*. 2002;43:927–935.
21. Lamoureux EL, Pallant JF, Pesudovs K, Rees G, Hassell JB, Keeffe JE. The impact of vision impairment questionnaire: An assessment of its domain structure using confirmatory factor analysis and Rasch analysis. *Invest Ophthalmol Vis Sci*. 2007;48: 1001–6.
22. Rasch G. *Probabilistic Models for Some Intelligence and Attainment Tests*. Chicago: University of Chicago Press; 1960.
23. Andrich D, Lyne A, Sheridan B, Luo G. *RUMM 2020*. Perth: RUMM Laboratory; 2003.
24. van Alphen A, Halfens R, Hasman A, Imbos T. Likert or Rasch? Nothing is more applicable than good theory. *J Adv Nurs*. 1994;20:196–201.
25. Tennant A, McKenna SP, Hagell P. Application of Rasch analysis in the development and application of quality of life instruments. *Value Health*. 2004;7 Suppl 1:S22–6.
26. Smith EV. Detecting and evaluation the impact of multidimensionality using item fit statistics and principal component analysis of residuals. *J Appl Measure*. 2002;3:205–231.
27. Linacre J. *A User's Guide to Winsteps: Rasch-Model Computer Program*. Chicago: Mesa Press; 2002.
28. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. *Multivariate Data Analysis*. Sixth ed. NJ: Prentice Hall; 2005.
29. Byrne B. *Structural equation modeling with AMOS: Basic concepts, applications, and programming.* New Jersey: Lawrence Erlbaum Associates; 2001.
30. Bentler PM. Comparative fit indexes in structural models. *Psychol Bull*. 1990;107:238–46.
31. Kline R. *Principles and practice of structural equation modeling.* 2nd ed. New York: Guilford Press; 2005.
32. Masters G. A Rasch model for partial credit scoring. *Psychometrika*. 1982;47:149–174.
33. Lamoureux E, Ferraro J, Pallant J, Pesudovs K, Rees G, Keeffe J. Are standard instruments valid for the assessment of quality of life and symptoms in glaucoma? *Optom Vis Sci.* 2007;84:789–796.
34. Tennant A, Pallant J. Unidimensionality matters (A tale of two Smiths?). *Rasch Measurement Transactions*. 2006;20:1.
35. Rovner BW, Casten RJ. Neuroticism predicts depression and disability in age-related macular degeneration. *J Am Geriatr Soc*. 2001;49:1097–100.
36. McGwin G, Jr., Chapman V, Owsley C. Visual risk factors for driving difficulty among older drivers. *Accid Anal Prev*. 2000;32:735–44.
37. Hassan SE, Lovie-Kitchin JE, Woods RL. Vision and mobility performance of subjects with age-related macular degeneration. *Optom Vis Sci*. 2002;79:697–707.
38. Klein BE, Moss SE, Klein R, Lee KE, Cruickshanks KJ. Associations of visual function with physical outcomes and limitations 5 years later in an older population:The Beaver DamEye Study. *Ophthalmology*. 2003;110:644–50.
39. Gragoudas ES, Adamis AP, Cunningham ET, Jr., Feinsod M, Guyer DR. Pegaptanib for neovascular age-related macular degeneration. *N Engl J Med*. 2004;351:2805–16.
40. Rosenfeld PJ, Rich RM, Lalwani GA. Ranibizumab: Phase III clinical trial results. *Ophthalmol Clin North Am*. 2006;19:361–72.
41. Rosenfeld PJ, Brown DM, Heier JS, Boyer DS, Kaiser PK, Chung CY, Kim RY. Ranibizumab for neovascular age-related macular degeneration. *N Engl J Med*. 2006;355:1419–31.
42. Heier JS, Antoszyk AN, Pavan PR, Leff SR, Rosenfeld PJ, Ciulla TA, Dreyer RF, Gentile RC, Sy JP, Hantsbarger G, Shams N. Ranibizumab for treatment of neovascular age-related macular degeneration: A phase I/II multicenter, controlled, multidose study. *Ophthalmology*. 2006;113:642 e1–4.