Ophthalmic Epidemiology, 15:224–233
ISSN: 0928-6586 print / 1744-5086 online

DOI: 10.1080/09286580802256559

informa healthcare

An Evaluation of the 10-item Vision Core Measure 1 (VCM1) Scale (the Core Module of the Vision-Related Quality of Life scale) Using Rasch Analysis

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ABSTRACT

***Purpose*: To assess and re-engineer the Vision Core Measure 1 (VCM1) questionnaire in low vision (LV) and cataract participants using Rasch analysis. *Methods*: 295 participants drawn from a low vision clinic and 181 from a cataract surgery waiting list completed the 10-item VCM1. Unidimensionality, item fit to the model, response category performance, differential item functioning (DIF) and targeting of items to patients were assessed. Category collapsing and item removal were considered to improve the questionnaire. *Results*: The initial fit of the VCM1 (combined populations) to the Rasch model showed lack of fit ($\chi 2 = 83.3$, df = 50, p = 0.002). There was evidence of DIF between the two populations which could not be resolved. Consequently, each population was assessed separately. Irrespective of the population, disordering of response category thresholds was evident. However, collapsing categories produced ordered thresholds and resulted in fit to the Rasch model for the LV (Total $\chi 2 = 41.6$, df = 30; p = 0.08) and cataract population (Total $\chi 2 = 17.9$, df = 20, p = 0.59). Overall, the VCM1 behaved as a unidimensional scale for each population and no item showed evidence of DIF. Item targeting to patients was however sub-optimal particularly for the cataract population. *Conclusion*: The VCM1 questionnaire could be improved by shortening the response scale, although different response categories are required for cataract and LV populations. Calibration of items also differed across populations. While the VCM1 performs well within the Rasch model, in line with its initial purpose, it requires the addition of items to satisfactorily target low vision and cataract populations.**

INTRODUCTION

Although objective vision impairment measures such as visual acuity are important, a comprehensive assessment of ophthalmic outcomes should also include measurement from the patient's point of view.[1] Patient-centered functioning is usually assessed using questionnaires and over thirty vision-related quality of life instruments have been recently reviewed.[1–4] One of these is the Vision Core Measure1 (VCM1), the core component of the Vision-Related Quality of Life (VQOL), developed in Great Britain for individuals with visual impairment.[5] The 10-item VCM1 scale assesses the patient's global feelings and perceptions associated with visual impairment so could be termed a quality of life (QOL) measure.

The VCM1 has been used for cataract surgery and low vision rehabilitation, using a summary score or a mean value.[6–10] Summary scoring, also termed Likert scoring, allocates an ordinal assignment of a numerical value to a participant's response. However, one limitation of this system is the erroneous assumption that it produces an interval scale. The validity of summary scores has been questioned by modern test theory, which includes Rasch analysis.[1,11–13] Rasch analysis provides estimates of measures on a linear interval scale.[1,14,15] It also calculates item difficulty in relation to person ability and assesses the scale validity in particular the item and person fit to the

Received 23 March 2008; accepted 17 May 2008
Keywords: VCM1, Rasch analysis, low vision, cataract, quality of life
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overall construct.[16–19] Critically, Rasch analysis can assess if the items used are appropriately targeted at the population being assessed.[1,20,21]

The conventional psychometric attributes of the VCM1 have been reported,[5,22] but the ability of the scale to provide fundamental measurement has not been empirically demonstrated. Given the substantial advantages offered by Rasch analysis and that the VCM1 questionnaire has been used with cataract and low vision patients,[9,10,23] we assessed its validity and measurement properties in these two important ophthalmic populations using Rasch analysis.

METHODS

Participants

First time referrals to low vision rehabilitation centers across Victoria (a southern state of Australia) participated in this study. An ophthalmologist report, providing the cause of vision loss and visual acuities, was required for each participant. The eligibility criteria included best presenting visual acuity (VA) $<$ 6/12 (or $>$6/12 with restricted fields), $\geq$18 years of age and the ability to converse in English.

Participants with cataract were drawn from the public surgery waiting list of the ophthalmology service at Flinders Medical Centre, Adelaide (South Australia). All patients on this list had been previously assessed in the eye clinic and reported difficulty performing everyday tasks because of their vision. They all had cataract, the removal of which was judged to be likely to remove their visual disability. By these criteria, they were listed for cataract surgery.[24] Other inclusion criteria were aged 18 years or older, no severe cognitive impairment and ability to converse in English without the need for an interpreter. Ethical approval was obtained for both populations and a consent form was signed by each patient who agreed to participate. This research adhered to the tenets of the Declaration of Helsinki.

The VCM1

Similar to the VQOL,[5] the Impact of Visual Impairment (IVI) questionnaire[25] used the 10 items of the VCM1 as its core (Table 1). The VCM1 includes content related to the overall construct of quality of life feelings and perceptions associated with visual impairment (QoL). The content of these 10 items is best considered to be quality of life as they pertain to concerns and feelings. There are no visual disability or activity limitation items. All participants completed the IVI but we are however reporting only the participants' responses to the ten VCM1 items in this manuscript. The IVI has been assessed using Rasch analysis previously,[26] whereas the 10 core items have not, but have been used alone as a measure by others.[10,23,27,28] All items are preceded by "In the past month . . . " and VCM1 item responses were assigned the following numerical values; "not at all" (0), "very rarely" (1) "a little of the time" (2) "a fair amount of the time" (3) "a lot of the time" (4) and "all the time" (5). According to its conventional validation,[5] it was expected that the items of the VCM1 will conform to a unidimensional and interval scaling.

Table 1. The 10 items of the Vision Core Measure1 (VCM1) questionnaire "In the past month . . . "

1. How often has your eyesight made you concerned or worried about your general safety at home?
2. How often has your eyesight made you concerned or worried about your general safety outside of your home?
3. How often has your eyesight stopped you from doing the things you want to do?
4. Have you felt embarrassed because of your eyesight?
5. Have you felt frustrated or annoyed because of your eyesight?
6. Have you felt lonely or isolated because of your eyesight?
7. Have you felt sad or low because of your eyesight?
8. How often have you worried about your eyesight getting worse?
9. How often has your eyesight made you concerned or worried about coping with everyday life?
10. How much has your eyesight interfered with your life in general?

Rasch analysis

The VCM1 data, from the two populations combined (cataract and low vision), were initially assessed for fit to the Rasch model[29] using the RUMM2020 software (RUMM Laboratory, Perth, Australia).[30] The Rasch model assumes that the probability of a respondent affirming an item is a logistic function of the relative distance between the item location and the respondent location on a linear scale. Hence, it is anticipated that the probability of endorsing a particular rating category will increase monotonically with the difference between the respondent's level of QoL in performing daily activities and the level of QoL required for the task. Where the data meet the Rasch model expectations, a transformation of the ordinal raw score into a true Rasch scale is achieved.[31,32]

To facilitate the interpretation the VCM1 rating scale, the scoring was reversed for the Rasch analysis (0 as 5, 1 as 4, 2 as 3, 3 as 2, 4 as 1, and 5 as 0). A positive item, measured in logits (the unit of measure used by Rasch for calibrating items and measuring persons) on the Rasch scale indicates that the item requires a higher level of vision-specific QoL than the mean of the items, while a negative item logit suggests that the item requires a lower level of vision-specific QoL than the average. A positive person logit score suggests that the person's level of vision-specific QoL is higher than the mean required level of vision-specific QoL for the items. Conversely, if a person logit score is negative, the person's perceived level of vision-specific QoL is lower than the average required level of vision-specific QoL.

Four overall performance statistics are considered. Two are Fit statistics which 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 mean square 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.

An item-trait interaction score reported as a Chi-Square (χ^2), which reflects the property of invariance across the trait, is also provided. This is calculated by adding the chi-square values for the individual scale items with the determination of significance using the associated summated degrees of freedom. A non-significant Bonferroni-adjusted probability value (p = 0.005: 0.05/10 VCM1 items) suggests no substantial deviation from the model and indicates that the hierarchical ordering of the items is consistent across all levels of the underlying trait. A person separation reliability score ranging between 0 and 1 indicates how well the items of the instrument separate the respondents.

A person separation reliability (PSR) score ranging between 0 and 1 indicates how well the items of the instrument separate the respondents. For example, a PSR value of 0.7 represents the ability to distinguish two distinct strata of person ability.[33,34] A value of 0.9 represents the ability to distinguish four strata of person ability.

In the event of misfit, removal of items is considered if they demonstrate fit residual values >2.5 or less than Bonferroni-adjusted probability scores (p = 0.005 (0.05/10 items). The presence of disordered thresholds is also determined. Disordered thresholds occur when participants have difficulty discriminating between the response options. This means literally that a category expected to be "harder" than an adjacent category was actually "easier," but often represents interchangeability of categories. Category collapsing is often the solution to disordered thresholds, which can improve overall fit to the model.

Misfit of the data to the Rasch model could also be linked with differential item functioning (DIF) where different groups within the sample (e.g. gender, eye disease, levels of visual acuity, etc), despite equal levels of the underlying trait, respond differently to an individual item. DIF can be detected both graphically and statistically using analysis of variance comparing scores across each level of the person factor and across different levels of trait (referred to as class intervals).

Unidimensionality provides further evidence that the instrument is measuring the underlying trait (quality of life) that it purports to measure. The unidimensionality of the VCM1 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.[35]

Targeting was also assessed as it was important to determine if the VCM1 items were particularly suitable to assess quality of life associated with low vision or cataract. 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.

RESULTS

Participant characteristics

The characteristics of the low vision (n = 181) and cataract participants (n = 181) who completed the VCM1 are shown in Tables 2 and 3. Most participants were elderly, female and reported some general medical comorbidity. The majority of the low vision participants had age-related macular degeneration, and the majority of cataract participants had bilateral cataract and did not have ocular comorbidity. Notably, the cataract patients had better binocular visual acuity than the low vision patients, but this represents genuine differences between these clinical populations; patients present for cataract surgery at lower levels of impairment than people present for low vision care. The rate of cataract patients with visual acuity better than 6/12 is comparable to that reported in a British public cataract surgery waiting list.[23]

Table 2. Characteristics of the low vision participants (n = 295)

Age (y)	Mean ± SD	78.1 ±12.8
Gender	Men	106 (36%)
	Women	189 (64%)
Visual acuity	<6/12 to 6/18	126 (43%)
	<6/18 to 6/60	134 (45%)
	<6/60	35 (12%)
Main cause of vision loss	Age-related macular degeneration	163 (55%)
	Diabetic retinopathy	45 (15%)
	Glaucoma	35 (12%)
	Other	52 (18%)
Duration of vision impairment (y)	Median (min, max)	3 (0.4 – 84)
Comorbidity	"Yes"	242 (82%)
	"No"	53 (18%)
Comorbidity affect on daily living?	"Not at all"	57 (24%)
	"A little"	85 (35%)
	"A great deal"	100 (41%)

SD = standard deviation.

Table 3. Characteristics of the cataract participants (n = 181)

Age (y)	Mean ± SD	72.2 ±11.9
Gender	Men	71 (39%)
	Women	110 (61%)
Visual acuity	>6/12	120 (66%)
	<6/12 to 6/18	43 (24%)
	<6/18 to 6/60	18 (10%)
	<6/60	0 (0%)
	Awaiting second eye surgery	74 (41%)
Ocular comorbidity	"Yes"	46 (25%)
	"No"	135 (75%)
Duration of cataract (y)	Median (min, max)	2 (0, 31)
Systemic comorbidity	"Yes"	117 (65%)
	"No"	64 (35%)
Comorbidity affect on daily living?	"No impact"	14 (22%)
	"Moderately"	24 (37%)
	"A lot"	26 (41%)

SD = standard deviation.

Overall fit of the VCM1 combined data to the Rasch model

Since the item wording and response category choices are consistent across items it was appropriate to use a single Andrich rating scale in RUMM 2020 analysis.[36] Rasch analysis of the 10-item VCM1 showed lack of fit to the Rasch model with a significant Item-Trait Interaction total χ^2 probability value (p = 0.0000). Two items namely item 2- "*How often has your eyesight made you concerned or worried about your general safety outside of your home?*" and item 6 "*Have you felt lonely or isolated because of your eyesight?*" demonstrated extreme fit residual values and probabilities below the Bonferroni adjustment threshold. Removing these items produced more items with extreme fit residuals values (>2.5) and no improvement in the χ^2 probability value. There was also evidence of DIF between the two eye disease populations on a number of items. Therefore it was not appropriate to combine these two populations and it was decided to assess if the VCM1 was an appropriate scale to assess quality of life in each population separately.

Low vision

Rasch analysis of the VCM1 low vision data showed a lack of fit to the Rasch model with a significant Item-Trait Interaction (p = 0.0004). Examination of the pattern of item thresholds revealed disordered thresholds which necessitated collapsing of the categories. The response category 4 *"very rarely"* does not have a range along the quality of life scale where it is the most likely category to be selected. Therefore it is less likely to be endorsed by the participants and is used interchangeably with category 5 "*not at all*" (Figure 1).

Consequently, scores for the 10 items were recoded by collapsing the last two response categories to generate five categories (coded 443210). Following recoding, no item showed disordered thresholds. Rescoring produced a non significant overall Item-Trait Interaction probability value (Total $\chi^2 = 56$, df $= 40$; p $= 0.05$) indicating the VCM1 functioned within the Rasch model. The mean (SD) Fit Residual values were -0.3 (1.6) for items and −0.3 (1.1) for persons. Ideally, the mean and SD values are expected to approximate 0 and 1, respectively. All items showed Fit Residuals values <2.5 with Bonferroni adjusted probability scores >0.005 indicating no significant deviation from the model (Table 4). The PSR and Cronbach's alpha values were 0.89 and 0.90, respectively.

The person-item location map shown in Figure 2 displays the low vision participants' scores on the Rasch calibrated scale (on the left hand side) and shows the relative difficulty levels of each of the VCM1 items on the right hand side. Participants having the highest level of quality of life and the highest impact items are at the top of the diagram. Conversely, the participants having the lowest quality of life and the lowest impact items are at the bottom. The participants' range of quality of life (−3.3 to 3.7 logits) was found to be not significantly different from a normal distribution (Kolmogorov-Smirnov Z test

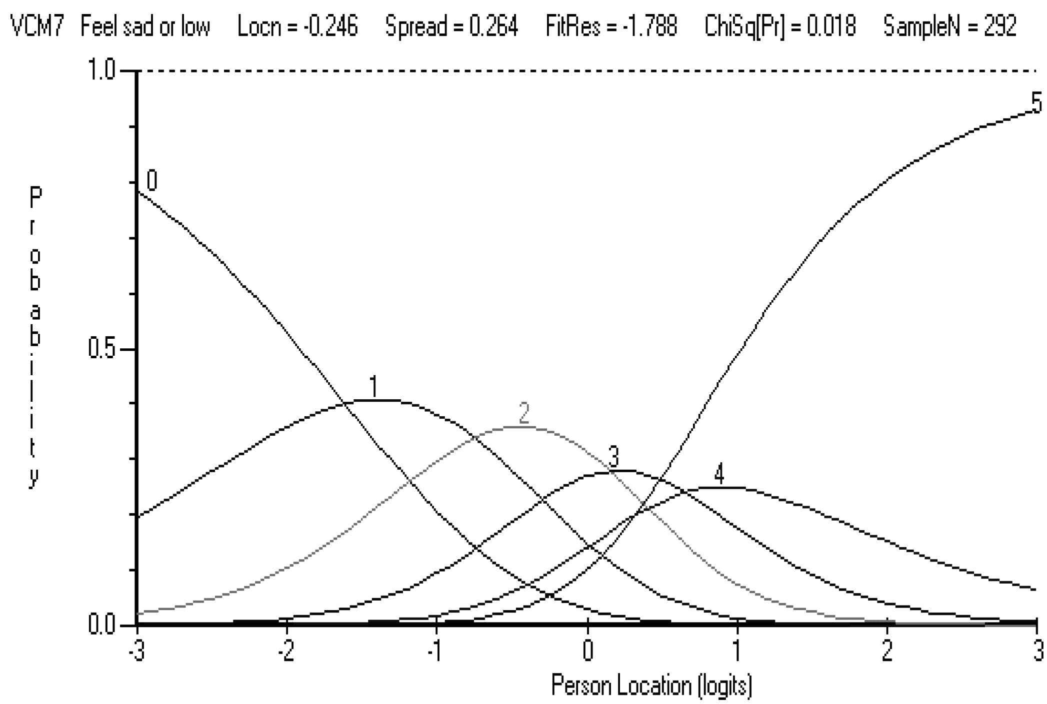

Figure 1. Category probability curves showing disordered thresholds for categories 4 in the low vision population. The response category 4 *"very rarely" '* does not have a range along the quality of life scale where it is the most likely category to be selected. Therefore it is less likely to be endorsed by the participants and is used interchangeably with category 5 "*not at all.*"

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----------------------------------------------------------
LOCATION       PERSONS            ITEMS
----------------------------------------------------------
High quality of life                    Most impact
  4.0                        |
                             |
                         ××× |
                             |
                             |
  3.0                        |
                      ×××××× |
                             |
                        ×××× |
                             |
  2.0                    ××× |
                       ××××× |
                        ×××× |
                    ×××××××× |
                      ×××××× |
  1.0         ×××××××××××××× |
              ×××××××××××××× |
              ×××××××××××××× | VCM3    VCM5    VCM8
                    ×××××××× | VCM10
               ××××××××××××× |
  0.0         ×××××××××××××× | VCM9
               ××××××××××××× | VCM2
                        ×××× | VCM7
                     ××××××× | VCM4
                      ×××××× |
 -1.0                 ×××××× | VCM1    VCM6
                             |
                        ×××× |
                         ××× |
                           × |
 -2.0                        |
                          ×× |
                          ×× |
                             |
                             |
 -3.0                        |
                             |
                           × |
                             |
                             |
 -4.0                        |
Low quality of life                Least impact
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Figure 2. Person-Item location map of the Rasch-scaled Vision Core Measure1 (VCM1) showing the distribution of calibrated low vision participants' scores (left hand side) and item locations (right hand side). Participants having the highest level of quality of life and the highest impact items are at the top of the diagram.

score = 0.57; p = 0.09). There was an uneven spread of items across the full range of the participant's scores which indicates a suboptimal item-person targeting for the low vision patients on the VCM1 scale. In addition, the mean person location logit value (0.6) indicates that overall, the questionnaire was not optimally targeted, with participants on average at a higher quality of life than the average of the scale items (which would be 0 logit). The two highest impact items were *"Worried about eyesight getting worse"* and *"Feeling frustrated or annoyed"* (0.77 and 0.76 logits, respectively). Conversely, the two lowest impact items were "G*eneral safety at home*" and "F*eeling lonely and isolated*" with logit scores of −0.89 and −0.83, respectively.

Cataract

The VCM1 data for the cataract population when fitted to the Rasch model produced a non significant Bonferroni adjusted Item-Trait Interaction p value (p = 0.006). The pattern of threshold ordering was different in this population (compared to the low vision), as there was no evidence of under-utilization for any category (Figure 3). The Person Separation Reliability value was 0.94.

All items showed Fit Residuals values <2.5 and Bonferroni adjusted probability scores >0.005 (0.05/10) (Table 5). The mean (SD) Fit Residual values were −0.2 (1.0) for items and −0.5 (1.3) for persons. Optimally, the mean and SD values are

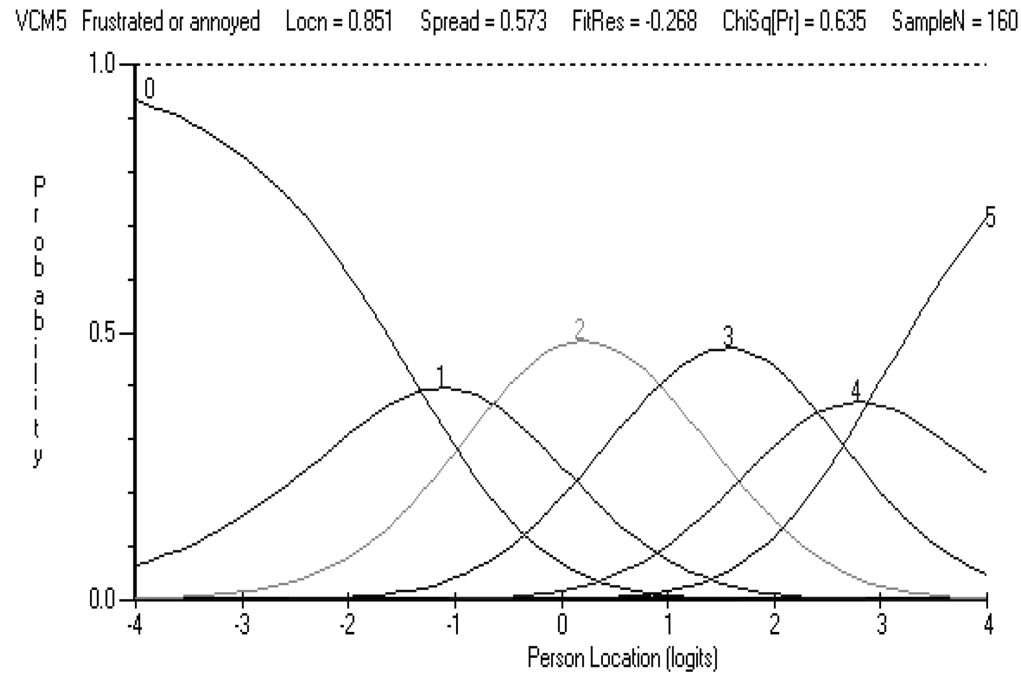

Figure 3. Category probability curve showing ordered response category thresholds for the cataract population. All categories were consistently endorsed by the participants with cataract.

expected to be close to 0 and 1, respectively. Figure 4 shows the Person-Item location map of the 10-item VCM1 for the cataract participants. The participants' range of quality of life (−2.9 to 4.9 logits) was found to be not significantly different from a normal distribution (Kolmogorov-Smirnov Z test score = 1.04; p = 0.22). There was an uneven spread of items across the full range of the participant's scores with almost no item located in the top half of the map. This finding indicates an ineffective item-person targeting for the cataract patients on the VCM1 scale. The mean person location logit value (2.0) provides further support that the questionnaire was not optimally targeted, with participants on average at a substantially higher level of ability than the average of the scale items (which would be 0 logit). The two most difficult items *"Worried about eyesight getting worse"* and *"Feeling frustrated or annoyed because of eyesight?"* (1.1 and 0.9 logits, respectively). Conversely, the two least difficult items were "F*eeling lonely and isolated*" and *"How much has your eyesight interfered with your life in general?"* with logit scores of −1.1 and −0.5, respectively.

Table 4. Category frequencies and Fit indices (location, fit residuals, chi-Square and probability values) of the 10 items to the Rasch model after rescoring (low vision population)

	Category response frequencies								
VCM1 Items	1	2	3	4	5	Location	FitResid	χ^2	Prob
1. Safety at home	7	29	35	70	148	–0.89	1.87	2.70	0.61
2. Safety outside of home	30	46	49	77	87	–0.11	1.55	0.66	0.96
3. Stopped you doing things	36	106	62	46	39	0.62	–0.11	11.05	0.03
4. Feel embarrassed	19	34	39	74	123	–0.53	0.41	1.87	0.76
5. Feel frustrated or annoyed	63	74	66	52	34	0.76	–1.95	9.22	0.06
6. Feel lonely or isolated	21	29	25	57	157	–0.83	0.77	9.16	0.06
7. Feel sad or low	27	47	43	68	104	–0.24	–1.98	12.14	0.02
8. Worried about eyesight	69	76	51	52	41	0.77	1.21	1.31	0.86
9. Coping with life	35	50	56	66	82	0.02	–1.03	5.97	0.20
10. Interfere with life	37	77	69	63	43	0.44	–3.38	1.67	0.80

FitResid = Fit Residuals, χ^2 = Chi-Square and Prob = probability score.
All items showed Fit Residuals values <2.5 and Bonferroni adjusted probability scores >0.005 (0.05/10).

Table 5. Category response frequencies and Fit indices (location, fit residuals, chi-Square and probability values) of the Rasch analyzed VCM1 scale (cataract population)

VCM1 Items	Category response frequencies 1	2	3	4	5	6	Location	FitResid	χ^2	Prob
1. Safety at home	1	6	8	36	41	66	–0.44	–0.04	4.60	0.10
2. Safety outside of home	4	6	18	42	34	53	0.11	0.94	0.51	0.77
3. Stopped doing things	1	14	18	44	35	47	0.27	–0.98	4.65	0.10
4. Feel embarrassed	2	8	9	39	23	78	–0.44	–0.03	3.39	0.18
5. Feel frustrated or annoyed	5	18	27	47	26	35	0.85	–0.27	0.91	0.63
6. Feel lonely or isolated	0	8	5	23	26	96	–1.13	–1.42	6.33	0.04
7. Feel sad or low	0	11	11	39	30	68	–0.27	–0.55	2.06	0.36
8. Worried about eyesight	11	11	31	59	25	22	1.11	1.70	8.06	0.02
9. Concerned coping with life	5	6	20	47	36	39	0.40	–1.73	0.40	0.82
10. Interfere with life	4	6	10	30	25	76	–0.46	0.09	8.80	0.01

FitResid = Fit Residuals, χ^2 = Chi-Square and Prob = probability score.
*All items showed Fit Residuals values <2.5 and Bonferroni adjusted probability scores >0.005 (0.05/10).

Differential Item Functioning (DIF)

The DIF method was used to determine whether different subgroups (age, gender, duration of visual impairment, level of visual impairment, comorbidity and impact of comorbidity on daily living) in the sample respond in the same way to the VCM1 items. In both populations, all items were found to be free from DIF, with probability values exceeding the adjusted alpha value for each of the person factors assessed.

Unidimensionality

Principal Components Analysis of the residuals identified two subsets of items consisting of the highest positive and negative loading items. Person estimates generated for these two subsets were subjected to independent t-tests to compare the estimates for each person. For the low vision participants, the negative subset (PC loadings <-0.3) represented three items pertinent to mobility and independence (*"Safety at home"; "Safety outside of home"*; and *"Stopped you doing things you want to do"*) and the positive subset (PC loadings >0.3) comprised four items related to emotional well being (*"Feel embarrassed"; "Feel frustrated or annoyed"; "Feel lonely or isolated";* and *"Feel sad or low"*). Similar subsets were also produced for the cataract group. Only 3.1% and 4.4% of estimates were found to be significantly different for the low vision and cataract populations, respectively. These values are less than the recommended cut point of 5% and therefore no evidence of multidimensionality was detected.

Discussion

We subjected the VCM1, a scale designed to assess patients' feelings about their visual impairment, to Rasch analysis to determine its measurement characteristics in participants with either low vision or cataract. When both populations were combined, there was evidence of misfitting items and DIF which indicated that the VCM1 questionnaire does not meet the standards of measurement defined by the Rasch model. However, when each population was assessed separately and following category collapsing in the low vision population, the VCM1 was found to be an appropriate scale to measure quality of life in each population. There was, however, evidence of sub-optimal item-person targeting in both populations which suggests that the performance of the instrument could be improved if other items were added to the core VCM1 items.

The performance of the response scale was different for the two populations. The low vision population consistently did not endorse response categories "*very rarely*" and *"a little of the time"*. Instead they used the categories relevant to people with greater quality of life impairment as one may expect in a low vision population. Collapsing these responses with adjacent ones resulted in a set of ordered responses which, in turn, improved the fit of the data to the Rasch model. The inconsistent endorsing or utilization of categories is not unusual in scales with many response options, or when the labeling of options are too similar to each other which can potentially be confusing or open to misinterpretation.

Our finding is consistent with other vision-specific scales which have benefited from a shortening of their response scales following Rasch analysis.[20,26,37,38] On the contrary, ordered thresholds were evident in the cataract population. It is notable that the response category labels are biased toward the less affected end of the scale with two categories for those minimally affected: *"very rarely," "a little of the time."* This cataract population, as is typical of modern cataract patients, is sufficiently affected by their condition to desire a safe and convenient surgical treatment, but remain mildly affected in the overall scheme of things with good visual acuity and relatively good quality of life. Therefore, the cataract patients had a more consistent utilization of the response categories at the milder end of the scale compared to the low vision people.

The Person-Item location maps showed that numerous participants recorded a positive person logit score which suggests that the person's level of feelings and perception is higher than the mean required level of feelings and perception for the items.

For the low vision population, this finding could be related to our participants being first time referrals to low vision rehabilitation, a relatively low median duration of vision impairment (3 years) and only a small number of participants (13%) considered severely vision impaired. Combined, these factors suggest that our low vision sample may not have been impaired enough to experience significant deterioration in quality of life associated with vision impairment. However, this hypothesis needs to be confirmed in further studies.

Similarly, the items were poorly targeted to the cataract population (Figure 4): most cataract patients had a better quality of life than addressed by the issues in the VCM1. Notably, the cataract patients had less visual impairment than the low vision population. One interpretation of the poor targeting could be that the cataract patients didn't really have visual related problems. However, all cataract patients were drawn from the cataract surgery waiting list, and the key indicator for cataract surgery is visual disability thought to be due to cataract.[39–41] Therefore, this population, by definition, has visual disability and this has been demonstrated previously.[24]

A better interpretation of the poor targeting of cataract patients is that the VCM1 simply doesn't contain content relevant to cataract patients. This has been argued previously in a study by Malik *et al*. who showed that 40% of cataract patients on a waiting list had minimal quality of life impairment as measured on the VCM1.[23] The underlying issue is that the VCM1 contains quality of life items rather than visual disability items. While this population has visual disability, their quality

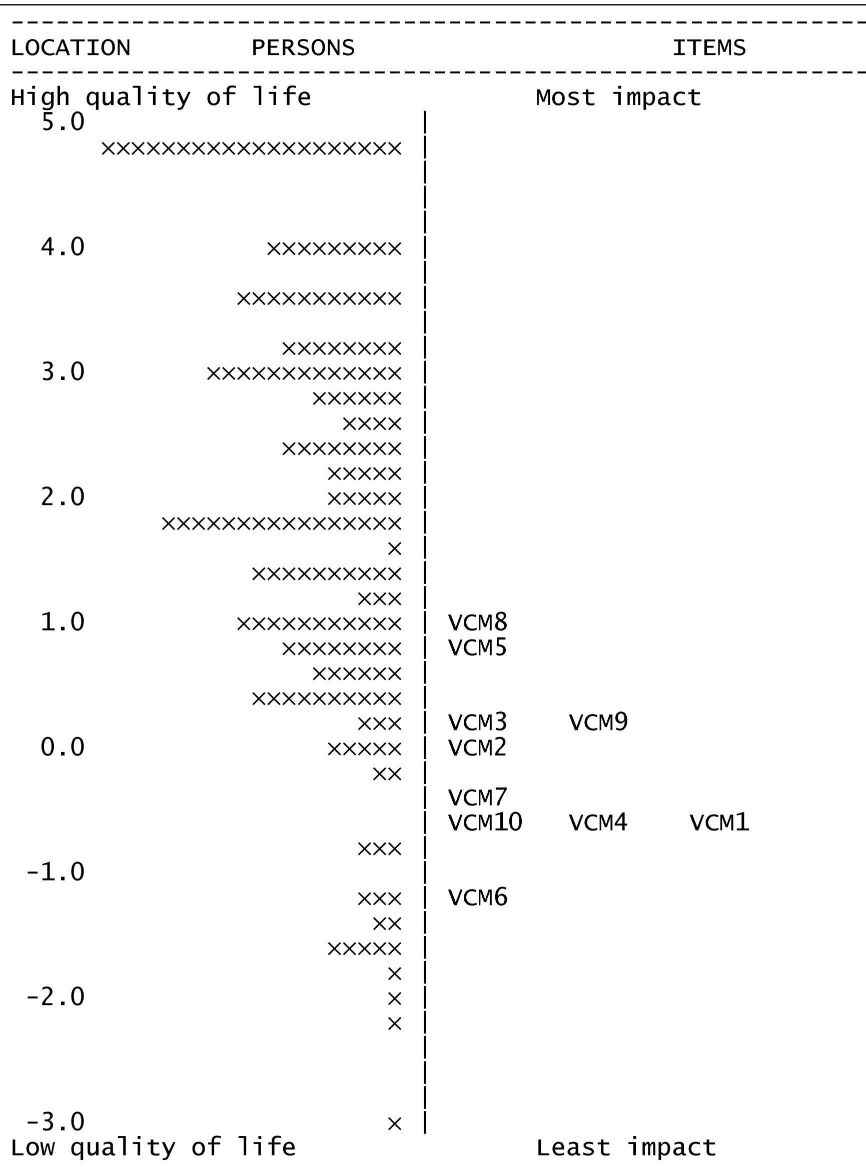

Figure 4. Person-Item location map of the Rasch-scaled Vision Core Measure1 (VCM1) showing the distribution of calibrated cataract participants' scores (left hand side) and item locations (right hand side). Participants having the highest level of quality of life and the highest impact items are at the top of the diagram.

of life was largely not affected by this. There may be fundamental reasons for this, for instance, cataract patients expect that surgery will remove their problems, so they don't have any long term concerns about visual impairment and its impacts. Regardless of the mechanism, it appears that the VCM1, on its own, is not a suitable outcome instrument for cataract patients. An instrument which specifically measures visual disability or a hybrid of the VCM1 and such an instrument would be more appropriate.

In conclusion, the application of Rasch analysis model does not support the structure of the original VCM1 and its rating scale (for the low vision group), which, in its raw form is essentially ordinal. The performance across the two disease groups differed and targeting was suboptimal, in particular in the cataract participants, suggesting that items should be added to optimize the instrument performance. The modified VCM1 scale did however achieve fit to the Rasch model for both populations.

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