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Rasch analysis of the Indian vision function questionnaire

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ABSTRACT

Aim To investigate the psychometric properties of the three scales (general functioning, psychosocial impact, visual symptoms) of the Indian vision function questionnaire (IND–VFQ) using the Rasch measurement model.

Methods 236 visually impaired patients referred to vision rehabilitation centres were administered the 33-item IND–VFQ. Rasch analysis was used to investigate the scales for the following properties: precision by person separation (ie, discrimination between strata of patient ability, recommended minimum value 2.0), unidimensionality (ie, measurement of a single construct) and targeting (ie, matching of item difficulty to patient ability).

Results Only the general functioning scale possessed adequate measurement precision (person separation 3.49). However, it lacked unidimensionality as some items did not contribute towards the measurement of a single construct indicating a secondary dimension. This comprised seven mobility items, which formed a separate valid subscale with good targeting (−0.57 logits). Deleting these items restored unidimensionality but a misfitting item required removal. Following this the 13 items fit and were visual functioning related. However, targeting was suboptimal (−1.13 logits).

Conclusions The general functioning scale of the IND–VFQ consists of two separate unidimensional constructs: visual functioning and mobility. Both these Rasch scaled versions with good psychometric properties are effective tools for the assessment of visually impaired patients in India.

Over the past two to three decades a number of instruments (questionnaires) have been developed to assess visual functioning in the visually impaired population and most have been designed for use in high-income countries. For example, the impact of vision impairment questionnaire (IVI) was developed in Australia to assess participation in daily activities by visually impaired individuals.[1] By comparison, only a few instruments have been designed for low-income countries such as India. One such instrument is the Indian vision function questionnaire (IND–VFQ).[2]

Like most instruments in ophthalmology, the IND–VFQ was also developed using traditional psychometric approach, ie, the classical test theory (CTT),[3] and has been reported to have strong psychometric properties.[4] However, the limitations of CTT are well known. A major limitation includes the sample dependency, meaning that both the person and item parameters in CTT are dependent on the test and examinee sample, respectively, and these dependencies limit the comparison across samples.[5] Therefore, CTT models are most useful when the sample upon whom the instrument is intended to be used is similar to the population for whom the instrument was developed. However, this is not practical as the sample differs in some unknown way from the population and can easily happen in a field test. Modern psychometric models, specifically Rasch analysis, offer several advantages over CTT. Most importantly, the property of invariance means that the item parameters and person estimates do not depend on the items administered or the people to whom the instrument is administered.[5] Currently, Rasch analysis is being used to develop new instruments in India, for example, the L V Prasad functional vision questionnaire[6] and evaluate existing ones, such as the visual function and quality of life questionnaires[7] developed for an Indian population to determine whether the assumptions of the Rasch model are met. The IND–VFQ has not yet been examined using Rasch analysis.

Recently, using Rasch analysis, three subscales of the IVI (accessing information, mobility and independence, and emotional wellbeing) were shown to be valid in a visually impaired population.[8] Using Rasch analysis, the present study explored whether the three scales of the IND–VFQ (general functioning, psychosocial impact and visual symptoms) are valid in a visually impaired population in India. This approach aims to provide the rationale for revising and improving the measurement qualities of the IND–VFQ. Consequently, if deficiencies were encountered then we intended to remedy these in an effort to improve the measurement properties of the IND–VFQ. In addition, we aimed to provide spreadsheets that convert raw to Rasch-scaled scores for those who wish to utilise the benefits of interval-level measurement.

METHODS

Indian vision function questionnaire

The IND–VFQ consists of 33 items divided into three scales—general functioning (21 items), psychosocial impact (five items) and visual symptoms (seven items). Participants rate the amount of difficulty in performing a given activity on a four-point scale for the two scales—'psychosocial impact' and 'visual symptoms'. The response options range from 1 ('not at all') to 4 ('quite a lot'). An additional category scored as 5 ('cannot do this because of my sight') exists for the third scale—'general functioning' so this was rated on a five-point scale by the participants. An item is coded as 'not applicable' if the participant is unable to perform the activity due to non-visual reasons. A high score represents greater difficulty with general function, higher psychosocial impact and greater visual symptoms for the three scales, respectively.

Subjects

Participants were adults with low vision referred to the Vision Rehabilitation Centres, L V Prasad Eye Institute, India, for the management of low vision. A single interviewer administered the IND−VFQ in a face-to-face interview to each participant.

Included in the study were those participants aged 18 years or older, who had low vision (best-corrected visual acuity in the better eye <6/18 or ≥6/18 with restricted visual fields) and who could respond to the instrument. Participants with additional disability (physical, hearing, etc.) were excluded as also were those who were totally blind in both eyes (bilateral absence of light perception). Ethical approval was obtained from the L V Prasad Eye Institute Ethics committee and all participants provided informed consent. The study was conducted in accordance with the tenets of the Declaration of Helsinki.

The sociodemographic data were extracted from the clinical records. Participant characteristics of those who provided responses to IND−VFQ are shown in table 1.

Procedures

Each participant underwent assessment for comprehensive low vision rehabilitation. Distance visual acuity (habitual and best spectacle corrected) was recorded for each eye using the Bailey−Lovie chart and measurements were based on logMAR principles.[9]

Rasch analysis

The matrix of responses from 236 participants was subjected to Rasch analysis using the Andrich rating scale model for polytomous data.[10] There are a series of components to Rasch analysis that have been described elsewhere in detail.[11] The basic purpose of Rasch analysis is to test how well the observed data fit the expectations of the Rasch measurement model.[12] Rasch analysis converts the raw ordinal data from responses to items into interval level data and the unit is logits (log-odd units).

Winsteps software[13] (V3.68) was used to conduct the Rasch analysis, and estimates of person ability and item difficulties were obtained. In brief, we assessed the following properties: behaviour of rating scale, measurement precision (using person separation), unidimensionality, targeting and differential item functioning (DIF). Person separation of 2.0 was considered the minimum acceptable value, which indicated that three strata of participant abilities could be distinguished by the IND−VFQ.[11] Unidimensionality (ie, whether all the items in a scale measure a single construct) was assessed using fit statistics and principal components analysis (PCA) of residuals. We report fit statistics as information weighted fit or infit mean square statistics (expected value is 1.0) and the suggested limits are 0.7−1.3.[11] Items with mean square values outside this range were considered as misfitting and such items should be iteratively removed from the instrument.[11] In addition to fit statistics, PCA of residuals was used to examine whether a substantial factor existed in the residuals after the Rasch factor (ie, primary measurement dimension) has been extracted. We used the following two criteria for this purpose: (1) a cut-off of variance of 60% accounted for by the first factor (ie, principal component); and (2) secondary dimension (or the first contrast in the residuals) should have the strength of at least two items (as measured by an eigenvalue >2.0) to be considered a second dimension, which was greater than the magnitude seen with random data.[14] If these criteria were fulfilled, then the results would be considered to support unidimensionality. Targeting refers to how well the item difficulties are aimed to match the performance level of the target population. Consequently, for a well-targeted instrument, the mean item difficulty (this is usually set at zero) would match the mean person ability of the population; the greater the difference between the means, the poorer the targeting.[15 16] For DIF analysis we selected the DIF variables (age, gender, systemic comorbidity, duration of vision loss, education and visual acuity group) a priori for this study. DIF was investigated for age (median age 38 years; younger <38 years and older ≥38 years), gender, systemic comorbidity (present or absent), duration of vision loss (median 10 years; shorter as <10 years and longer as ≥10 years), education (illiterate or literate) and visual acuity (group; better as ≥20/200 and worse as <20/200). DIF was considered to be absent if it was less than 0.50 logits, and minimal (but probably inconsequential) if between 0.50 and 1.0 logits and notable if more than 1.0 logits.[7]

Examination of the psychometric properties of the rating scale should be performed before assessing other attributes in Rasch analysis. In particular, we assessed the response format for the location of the thresholds (point at which participant has a 50% chance of choosing one category over another) using category probability curves. For a good fitting model, one would expect thresholds to increase monotonically, failing that they are considered disordered and category re-organisation is done post-hoc.

The minimum acceptable measurement properties of the Rasch models for a scale to be termed as a measure included adequate measurement precision (ie, person separation). If this criterion was not fulfilled despite repair, then higher measurement properties such as dimensionality and DIF were not assessed.

Descriptive statistics were analysed using SPSS software (V.16.0).

Table 1 Sociodemographic and clinical characteristics of the 236 participants who completed the IND−VFQ

Characteristic	n (%*) or mean±SD
Age (years)	39.7±17.5
Gender	
Men	182 (77)
Women	54 (23)
Visual acuity in better eye	
≥6/18†	52 (22)
<6/18−6/60	110 (47)
<6/60	74 (31)
Mean visual acuity in better eye	
LogMAR (Snellen)	0.88±0.49 (6/48^{+1})
Range	0.0 to 2.00 (6/6 to light perception)
Education level	
Illiterate	25 (11)
Up to 9 years	53 (22)
10−12 years	77 (33)
>12 years	81 (34)
Duration of vision loss (years)	
Median	10
Systemic comorbidity‡	
Present	61 (26)
Absent	173 (74)

*Percentages have been rounded off to the nearest digit.
†These patients had restricted visual fields (<20° in better eye).
‡Includes diabetes, hypertension, asthma, coronary artery disease and data were missing for two cases.
IND−VFQ, Indian vision function questionnaire.

Table 2 Overall performance of the native version, 13-item visual functioning scale and seven-item mobility scale of the revised IND−VFQ

Versions	IND−VFQ (native version)			General functioning (revised version)		
	General functioning	Psychosocial impact	Visual symptoms	Visual functioning		Mobility subscale
No of items	21	5	7	14	13	7
No of misfitting items	1	1	2	1	0	0
Person separation	3.49	1.59	1.98	2.52	2.51	2.96
Mean item location	0	0	0	0	0	0
Mean person location	−0.86	−0.26	0.11	−1.02	−1.13	−0.57
PCA—eigenvalue for first contrast (%)	3.4 (6.6)	–	–	2.0 (5.8)	1.9 (5.3)	2.0 (8.1)
DIF (no of items)	3	–	–	3	3	1

DIF, differential item functioning; IND−VFQ, Indian vision function questionnaire; PCA, principal components analysis.

RESULTS

Analysis of response categories

The response category thresholds demonstrated ordered behaviour for all the three scales indicating that the participants used the categories as they were intended to, so the original rating scale format was retained.

Overall performance of scales

The person separation was below acceptable limits for two of the three scales, ranging from 1.59 to 1.98, indicating that the scales had suboptimal discrimination abilities (table 2).

However the remaining scale—'general functioning' showed adequate person separation of 3.49 so this was analysed further and the results are presented below.

General functioning scale

The separation between the mean item and participant score was 0.86 logits indicating mistargeting between the item difficulties and participant abilities (participants had higher abilities than the difficulty posed by the items) as shown in the person-item map. There was one item that misfit—'Because of your vision how much problem do you have in seeing outside in bright sunlight?'. PCA of residuals showed that the variance explained by the measures was 60.1% and the unexplained variance explained by the first contrast was 3.4 eigenvalue units, wherein seven items (all mobility related) loaded positively (>0.4) onto the first contrast. There were no additional contrasts. Three items showed minimal DIF by education status (table 3).

Given the item misfit and results of PCA, the scale lacked unidimensionality. The way forward to restore unidimensionality was to delete the seven mobility-related items from the scale. Following deletion, the remaining 14 items were unidimensional. However, one item misfit and this was the same as that of the general functioning scale. This misfitting item was deleted resulting in a final set of 13 items that fit the Rasch model and represented 'visual functioning or VF'. However, compared with the native version, targeting had worsened (by 0.27 logits), albeit marginally. This indicated that the participants' visual functioning was greater than that captured by the items (figure 1). Three items showed minimal DIF by education status and gender (table 3).

Rather than discard the seven mobility-related items we investigated whether these items could be used to form a separate mobility subscale with valid measurement properties and this analysis is presented below.

Table 3 Items showing DIF in the native and revised versions of the IND−VFQ

Item	Demographic variable	
	Education status	Gender
Seeing if there are animals or vehicles while walking	Literates* (0.53)	–
Finding your way indoors	Literates* (0.64) Literates† (0.82)	Men† (0.65)
Seeing when coming into the house after being in sunlight	Illiterates* (0.88) Illiterates† (0.79)†	–
Locking or unlocking the door	–	Women† (0.52)
Going out at night	Illiterates‡ (0.84)	–

All values are in logits (ie, log of OR or the log-odds of the level of difficulty of an item relative to the difficulty of the total set of items analysed) and the listed subgroups rated these items as easier relative to other activities by the amount of logits indicated in parentheses.
*Native version of general functioning scale.
†Revised version 13-item visual functioning scale.
‡Revised version seven-item mobility scale.
DIF, differential item functioning; IND−VFQ, Indian vision function questionnaire.

Mobility subscale

This seven- item subscale had adequate person separation and was unidimensional. The separation between mean item and participant score was better, albeit marginally, than the full version (ie, general functioning scale) (figure 2). One item showed minimal DIF by education status (table 3).

Criterion validity

There was a fair and statistically significant relationship ($r=0.38$, $p<0.0001$) between the visual acuity in the better-seeing eye and the 13-item Rasch-scaled visual functioning score. Likewise, there was a fair and statistically significant relationship ($r=0.25$, $p<0.0001$) between the visual acuity in the better-seeing eye and the seven-item Rasch-scaled mobility score.

Conversion from raw to Rasch-scaled scores

It would be ideal for the users of the revised versions of the IND−VFQ to perform Rasch analysis on their own data as populations vary. However, investigators can use our ready-to-use spreadsheets that convert raw to Rasch-scaled scores, thereby utilising the scoring benefits of Rasch analysis. These sheets can be obtained by contacting the first author or can be downloaded from the journal's website. Nevertheless, it should be borne in mind that these conversions would apply only if the sample is similar to that of the present study.

DISCUSSION

Rasch analyses of the IND−VFQ revealed several flaws. Most importantly, the general functioning scale lacked unidimensionality as was comprehensively demonstrated by PCA of residuals, and the remaining two scales (psychosocial impact and visual symptoms) lacked the fundamental measurement property of a Rasch measurement model, ie, inadequate measurement precision.

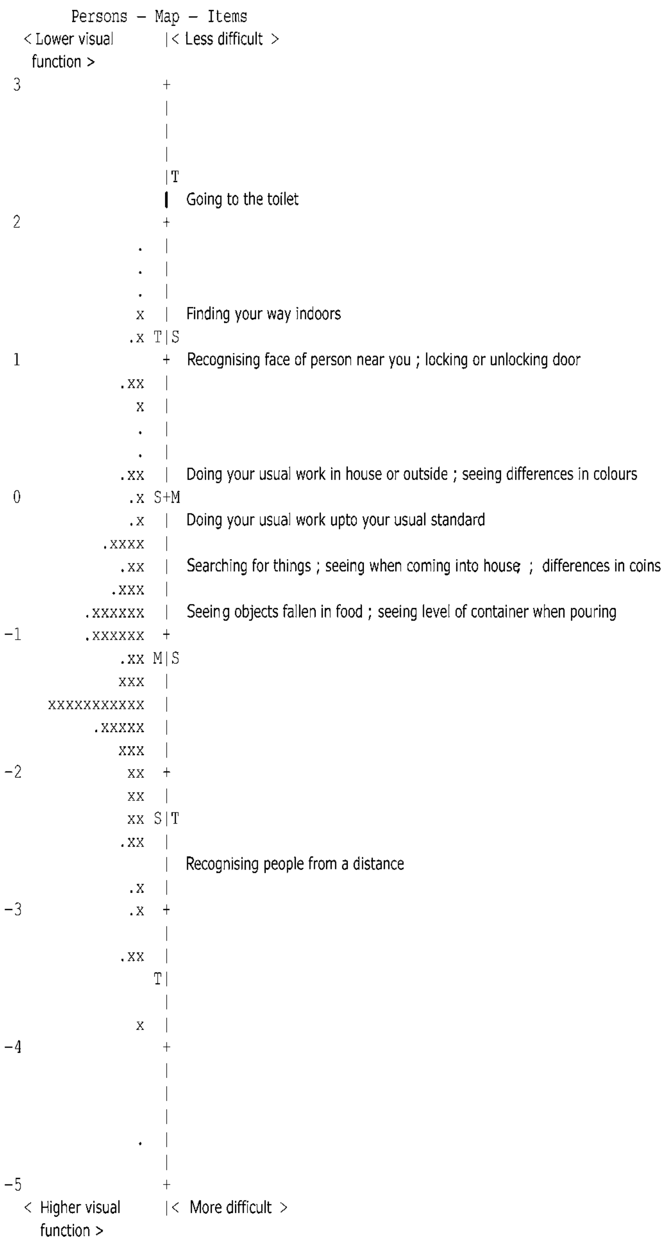

Figure 1 Person-item map of the 13-item visual functioning scale of the revised Indian vision function questionnaire. Participants are located on the left of the dashed line and those with lower visual function are located at the top of the map. Items are located on the right of the dashed line and less difficult items are also located at the top of the map. Each 'x' represents three participants and each '.' represents one to three participants. M, mean; S, 1 SD from the mean; T, 2 SD from the mean.

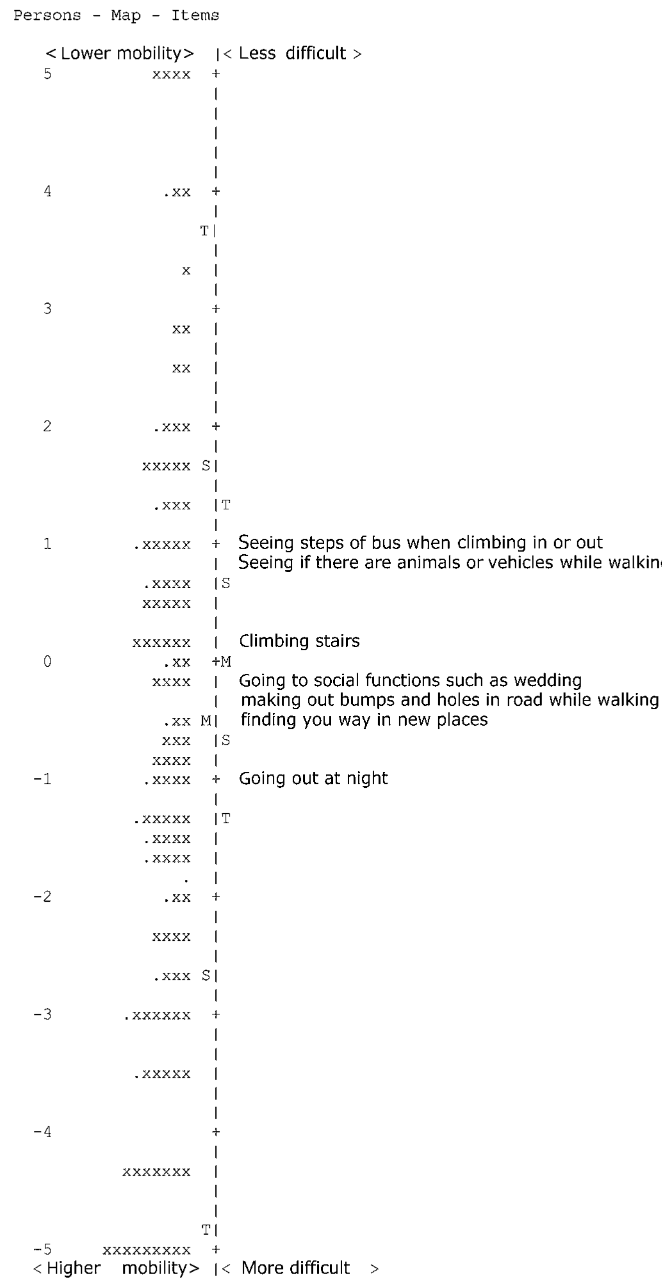

Figure 2 Person-item map of the seven-item mobility subscale of the revised Indian vision function questionnaire. Participants are located on the left of the dashed line and those with lower mobility are located at the top of the map. Items are located on the right of the dashed line and less difficult items are also located at the top of the map. Each 'x' represents two participants and each '.' represents one to two participants. M, mean; S, 1 SD from the mean; T, 2 SD from the mean.

Lack of unidimensionality has important implications because under these circumstances the use of a summary scale score is invalid.[17] Results of the present study further indicate that the general functioning scale is not measuring a single construct; instead it is measuring two constructs—visual functioning and mobility. The misfit of the mobility items when they are sequestered in a visual functioning scale is not a unique finding in visually impaired patients and has also been reported by other investigators.[18] Other instruments such as the IVI[19] and 'activity breakdown structure'[18] that were developed for visually impaired patients in high-income country settings have confirmed presence of a separate valid mobility subscale.

Measurement precision was grossly inadequate for the psychosocial impact scale, as was evidenced by poor person separation indicating that this scale could reliably distinguish among only two groups of participants, ie, lower versus higher psychosocial impact. The person separation was, however, borderline for the visual symptoms scale and it is plausible that it may reach a value of 2.0 in another population, thereby rendering it a reliable scale. Nonetheless, a simple strategy to increase the reliability would be to add items so as to increase the range of psychosocial issues and visual symptoms that impact chronic vision impairment. However, the addition of items lies within the purview of the developers of IND–VFQ, so was not pursued in the present study. Using CTT, however, both the psychosocial impact and visual symptoms scales were demonstrated to have high reliability (Cronbach's α=0.88 for psychosocial impact as well as visual symptoms). In CTT, Cronbach's α is used as a reliability coefficient to represent the unidimensionality of an instrument, which was also the case with the IND−VFQ, and is often exaggerated by the number of items in the instrument.[20] According to Cronbach,[20] α estimates the 'proportion of test variance attributable to common factors among the items' and therefore high inter-item correlations can lead to high Cronbach's α (>0.90), which suggests a high degree of item redundancy.[21 22] Therefore, this limitation highlights the need either to use Rasch analysis in the development of instruments, for example, the L V Prasad functional vision questionnaire[6] and visual disability questionnaire[23] or during re-validation of instruments.[7 8 11 17 24]

Both the proposed Rasch versions of the IND−VFQ (the 13-item visual functioning and seven-item mobility scale) share features of a good measure: adequate measurement precision and items that measure a single construct (ie, visual functioning and mobility, respectively). However, there is one difference: the mobility scale has items that are well targeted to the participant ability (−0.57 logits) but the visual functioning scale has suboptimal targeting (−1.13 logits). Rasch versions of other similar instruments, albeit developed for high-income country settings such as the IVI[8] and National Eye Institute visual function questionnaire[24] have reported good targeting (0.18 logits for both).

Both the 13-item visual functioning scale and seven-item mobility scale could be used to evaluate the effectiveness of interventions aimed at improving the visual functioning and mobility of visually impaired in India. However, the effectiveness of both these scales in making rehabilitation plans would be delimited to those with low vision but not to those who are totally blind as they were excluded from our patient population (to avoid floor/ceiling effects). Furthermore, inclusion of totally blind patients could have served as a check to determine if these patients will interpret the items in extreme categories. Nevertheless, future studies could address this issue.

The IND−VFQ was developed a few years ago so the activities listed may not be challenging enough for visually impaired patients now and this may have led to suboptimal targeting of the visual functioning scale. While adding items (such as reading text/numbers on mobile, reading newsprint, reading from computer screen, etc.) relevant to the present visually impaired population in India could perhaps help overcome this problem, a better strategy would be the creation of an item bank for visual functioning in visually impaired patients and the use of computer-adaptive testing for its implementation.[25] In such a strategy items are presented based on the person's response to previous items, which tailors the presentation of items to the ability of participants.[25]

In conclusion, Rasch analysis of the IND−VFQ resulted in the formation of two separate unidimensional constructs, ie, the 13-item visual functioning and the seven-item mobility scale that enable measurement of these constructs in visually impaired patients in India. These could be used to evaluate the effectiveness of interventions aimed at improving visual functioning and mobility of visually impaired in India. Further work is being carried out to compare the targeting of the Rasch versions of the IND−VFQ and National Eye Institute visual function questionnaire so as to determine the most appropriate instruments for use in India.

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Patient consent Obtained.

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