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Visual and health outcomes, measured with the activity inventory and the EQ-5D, in visual impairment

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ABSTRACT.

Purpose: **Generic instruments to assess health utilities can be used to express the burden of health problems in widely used indexes. That is in contrast with what can be obtained with condition-specific instruments, outcomes are very specific and difficult to compare across conditions. The purpose of this study was to assess health and visual outcomes and its determinants in patients with visual impairment (VI) using the EQ-5D-3L and the Activity Inventory (AI).**

Methods: **Participants were recruited in different hospitals during the PCVIP-study. A total of 134 patients with acuity 0.30 logMAR or less in the better eye were interviewed. The AI includes 46 goals split between three objectives: social functioning, recreation and daily living, and was used to measure visual ability. The EQ-5D consists of five questions covering one domain each and was used to provide a measure of health states. Responses to each domain were combined to produce a single individual index.**

Results: **The AI and the EQ-5D-3L showed enough discriminatory power between VI levels ($p < 0.001$), and their results were strongly correlated $r(134) = 0.825$, ($p < 0.001$). Explanatory factors for visual ability were level of VI in better eye, age and gender, $R^2 = 0.43$, ($p < 0.001$). Explanatory factors for the EQ-5D-3L were level of VI in the better eye, comorbidities and gender, $R^2 = 0.36$, ($p < 0.001$).**

Conclusion: **Our results showed that the EQ-5D-3L is useful when characterizing the burden of VI and to compute, when necessary, quality-adjusted-life-years (QALY) changes due to VI. However, it is important to consider that the EQ-5D-3L uses a coarse response scale, assesses a limited spectrum of domains and is influenced by comorbidities. This might limit its responsiveness to small changes in visual ability.**

Key words: patient reported measures – utilities – visual ability – visual impairment

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Introduction

Patient-reported outcome measures are fundamental for evaluation of health technologies or interventions (Brazier 2007). To perform a complete assessment of the benefits of a health intervention, it is necessary to provide evidence of the effect of intervention on patients' health status and/or health-related quality of life. The type of instrument used to measure outcomes of health interventions must be designed to serve the specific requirements of the study question or the proposed application. Instruments to assess patient-reported outcome measures can be divided into several categories; however, the divisions should not be regarded as rigid or mutually exclusive (Fitzpatrick et al. 1998). The present study compares the performance of two categories of these measures, health utility and functional ability measures, in visually impaired patients.

Health utility measures express preferences or values attached to individual health states as a single number. Instruments commonly used to collect data on utilities include the EuroQol-EQ-5D (Brooks 1996; Langelaan et al. 2007; van Hout et al. 2012; Butt et al. 2013), the SF-6D (Espallargues et al. 2005; Butt et al. 2013), the Geriatric Depression Scale (Lyness et al. 1997) and other rating scale questionnaires. Health utilities typically are estimated from time trade-off (Weinstein et al. 2009) or standard gamble methods (Drummond et al. 1987), or from one of several stated-preference methods (e.g. discrete choice (Kessels et al. 2011), pairwise comparison (Bradley & Terry 1952), best-worst scaling

(Flynn et al. 2007) or iterative bidding games (Brookshire & Crocker 1981)). Health utilities are used to provide estimates of the overall value of health states to the individual and/or to society and are used in cost-utility analyses.

To simplify data collection, all likely combinations of ratings of the five items in the EQ-5D-3L, each of which represents a different health state, have been mapped to community-based health utilities by a representative sample of the community population using a time trade-off method (Ferreira et al. 2014). Therefore, the EQ-5D-3L can be administered as a rating scale questionnaire and a utility tariff, corresponding to the pattern of responses to the five items, can be looked up in a table (or estimated from an algorithm). The assigned utility values then can be used to estimate quality-adjusted life-years (QALYs; Rein et al. 2007). However, it often has been suggested that the EQ-5D-3L can have unreliable and unresponsive outcomes in the case of visual disorders (Tosh et al. 2012; Malkin et al. 2013).

The intent of health utilities is to have the scale referring only to the value of health states and not be disease-specific. The EQ-5D-3L, like most instruments, do not include items responsive to the effects of vision disorders when assessing health states. In the past, there have been attempts to develop separate vision-related utilities (Brown et al. 2003), but that approach has been criticized because it overestimates the utility of vision relative to that of overall health (Kymes 2008; Frick & Massof 2009).

Condition-specific (individualized) health state assessment instruments have item content targeted to specific symptoms and/or quality of life consequences, with many allowing respondents to select relevant items and/or rate the importance of each item (Fitzpatrick et al. 1998). Self-report instruments used to assess visual functioning include the National Eye Institute Visual Functioning Questionnaire (NEI-VFQ; Mangione et al. 2001), the Impact of Vision Impairment Questionnaire (IVI; Weih et al. 2002) and the Activity Inventory (AI; Massof et al. 2005a,b, 2007). In our study, the AI was adopted to estimate person measures, mostly because it has been developed and used specifically for individuals with low vision and we had access to the item calibration file (Massof et al. 2005 a,b; Goldstein et al. 2014). The advantage of using an instrument calibrated with hundreds of low-vision individuals is that the interaction between person's 'ability' and item's 'difficulty' can be modulated. A strength of such individualized self-report instruments is that they address the concerns of individual patients rather than impose community standards that may not be well informed or well targeted to the patient population of interest. Although sometimes criticized by strict methodologists, in the case of assessing the effect of VI or the impact of low-vision rehabilitation, it often is necessary to administer self-report visual functioning assessment instruments by interview because of the patients' vision limitations.

Given the high and growing prevalence and incidence of visual impairments from age-related eye diseases, policy makers need evidence about the burden of VI to develop effective and inclusive public health strategies (Binns et al. 2012). For example, with the aging of the population and elevated risks of adverse health events, it is necessary to know the impact of vision impairment on health states and the cost-utility of low-vision rehabilitation. In many European countries, Portugal in particular, these two topics remain poorly studied. A recent exhaustive critical review of the relevant literature concluded that more cost-effectiveness studies are necessary to understand the effectiveness of current low-vision rehabilitation practices (Binns et al. 2012). Without evidence of cost-effectiveness of interventions intended to tackle the burden of VI, two scenarios are likely: i) decision makers will reduce the availability of resources for this purpose or ii) allocated resources might be poorly managed due to undefined priorities. Therefore, for the correct evaluation of the burden of VI it would be desirable to use generic instruments to make estimated patient preferences directly comparable to other health state preferences.

The use of generic instruments to access health preferences of visually impaired people remains uncommon, but seems necessary. For example, Malkin and colleagues recently conducted one of the few studies to use a generic health state instrument, the EQ-5D-3L, to assess both the health utility of VI and the impact of low-vision rehabilitation (Malkin et al. 2013). The authors concluded that the EQ-5D-3L was unresponsive to low-vision rehabilitation, a conclusion supported by the results summarized by Tosh and colleagues who concluded that the EQ-5D-3L might have limited ability to distinguish between groups of patients, stratified by acuity, suffering from age-related macular degeneration or diabetic retinopathy (DR) (Tosh et al. 2012; Malkin et al. 2013). These studies demonstrate that the use of health utility measures with visually impaired patients requires further investigation, in particular to determine which factors other than visual acuity (VA) can influence health utilities in visually impaired people.

The purpose of our study was to investigate whether the EQ-5D-3L and the AI have equivalent ability to discriminate between VI categories and which factors can affect those measures. We hypothesize that generic (EQ-5D-3L) and condition-specific (AI) instruments have different abilities to discriminate between levels of VI and that each instrument is influenced by a different set of visual and non-visual factors.

Patients and Methods

Participant recruitment and data collection

Participants were recruited in three public hospitals as a part of a study of prevalence and costs of VI in Portugal (PCVIP-study). Outpatients at these hospitals with VA, measured with latest refractive correction prescribed, in the better seeing eye of 0.30 logMAR or lower were invited to take part in face-to-face interviews. Visual acuity (VA) was assessed using an internally illuminated ETDRS chart (Lighthouse International, New York, NY, USA) at 4, 2 or 1 m according with the severity of their vision loss. The room lights where extinguished during measurements. Letter-by-letter scoring was employed to specify final measured acuity (Ferris et al. 1982).

During interviews, participants were asked about 16 systemic health problems detailed in Table A1 in Appendix that are consistent with those assessed in other studies (van Nispen et al.

2009; Morales et al. 2010; Whitson et al. 2011). Demographic information and other descriptive information for our sample of 134 participants are summarized in Table 2. All questionnaires were administered during the interview and responses recorded in our digital platform for further extraction and analysis.

The present study was conducted in accordance with the tenets of the Declaration of Helsinki, reviewed and approved by the ethical commission for Life Sciences and Health of the University of Minho and hospitals ethics committees. Written informed consent was obtained from all participants.

Functional reserve given by the Activity Inventory (AI)

The AI is an adaptive visual function questionnaire designed to provide an individualized assessment of difficulties of a visually impaired respondent when performing valued activities. The AI consists of a hierarchal structure in which specific cognitive and motor vision-dependent tasks (e.g. pouring or mixing without spilling) underlie more global goals (e.g. preparing meals). Disabilities, or activity limitations according to the World Health Organization's International Classification of Functioning, occur when an individual reports abnormal difficulties in achieving important goals (van Leeuwen et al. 2015). Difficulties achieving a goal are said to depend on the difficulty experienced in the tasks that underlie each goal (Massof et al. 2005). The investigators translated the AI into Portuguese (Hernández-Moreno et al. 2015). In the Portuguese version, 46 goals divided among three objectives (social functioning, recreation and daily living) were used. Respondents first rated the importance of each goal with four possible responses ranging from 'not important' to 'very important'. Goals rated 'not important' were skipped, for goals rated 'slightly important' or above participants were asked to rate the goal's difficulty on a five-point scale ranging from 'not difficult' to 'impossible to do'. The 'difficulty' responses were Rasch analysed to produce a continuous measure of visual ability given by the variable *'person measure'* (Program WINSTEPS, v3.9; Winsteps.com). We use the term '*visual ability*' to define the overall ability to perform activities that depend on vision. Visual ability is likely to be affected by other conditions apart from VI such are chronic pain, fatigue or depression (Tabrett & Latham 2011).

Utility values given by the EQ-5D-3L

The EQ-5D-3L is a generic instrument for preference-based measures of health and is expected to provide a measure of health status (Brooks 1996; Dolan 1997). The EQ-5D-3L consists of five questions, each describing a different health state domain. The five domains are mobility (D1), self-care (D2), usual activities (D3), pain or discomfort (D4) and anxiety or depression (D5). Difficulties in each domain are classified using a three-point scale: 1 = 'no problems', 2 = 'some problems' and 3 = 'extreme problems or unable'. A respondent's overall health state is then defined by a vector representing the level for each domain; the combination of answers to five domains can generate 243 (3^5) unique vectors representing overall heath states. For example, the heath state vector [11111] would be generated by someone who does not have difficulty in any domain, whilst [32211] would be the responses of someone unable to move, some problems in self-care and usual activities and no problems in the last two domains. Each response vector is then transformed to a health utility using the EQ-5D-3L index for which 0 corresponds to a state over which immediate death is preferred and 1 corresponds to the state of 'perfect health'. A negative value would correspond to a health state 'worse than dead'. Utility index values used here were obtained from Ferreira and colleagues who published community tariffs for the EQ-5D-3L in the Portuguese population (Ferreira et al. 2014). During the questionnaire administration, clear instructions were given to consider difficulties associated with VI.

Categories of visual impairment (VI)

Visual impairment (VI) was categorized according to the guidelines of the International Council of Ophthalmology using VA intervals on a logMAR scale (International-Council-of-Ophthalmology 2002). In a logMAR scale, acuity can be calculated by adding the number of letters read considering a score of 0.02 per correct letter. For example, in an ETDRS chart designed to measure distance VA at 4 m, the top line corresponds to acuity 1.0 logMAR. Letters can be used to compute acuity using the formula: VA = 1.1–0.02xNL, where NL represents the number of letters read (Table 1).

Data analysis

Variables were tested for normality using the Kolmogorov–Smirnov test. ANOVA was used for multiple comparisons, and *t*-test was used to compare two distributions when the variables were normally distributed. Kruskal–Wallis or Mann–Whitney *U* tests were used for comparisons when variables failed normality tests. The null hypothesis was rejected for α values <0.05, when necessary Bonferroni correction was applied (0.05/number-of-comparisons). Associations between variables were tested with Pearson correlations when both variables were continuous and Spearman's rank-order correlation when any of the variables was ordinal. Descriptions of correlations ranged from 'very weak' (0.0–0.19) to 'very strong' (0.8–1) using Swinscow's classifications (Swinscow 1997). Vision-specific tools for quantifying visual ability and generic utility measures need to be compared with caution.

Table 1. Definition of level of visual impairment used to divide participants into groups.

Category description	Lower limit (Visual acuity)	Upper limit (Visual acuity)	Category number
No visual impairment	0.30 logMAR (0.5 decimal)	−0.30 logMAR	0
Minor VI	0.50 logMAR (0.32 decimal)	0.32 logMAR	1
Moderate VI	1.00 logMAR (0.10 decimal)	0.52 logMAR	2
Severe VI	1.30 logMAR (0.05 decimal)	1.02 logMAR	3
Profound VI/Blind	3.0 logMAR (0.00 decimal)	1.32 logMAR	

But comparisons have been tried in the past because they are necessary to gather information about the overall impact of vision loss in health (Espallargues et al. 2005; Crewe et al. 2011). To investigate whether final scores of our instruments were associated with the same factors, we conducted a regression analysis using as explanatory factors: age, gender, VI level in the better and in the worse eye and number of comorbidities. We included the level of VI in the worse eye because a study from Finger and colleagues in 2013 has shown that this could be relevant to explain reported health states, and we wanted to test this in both instruments used (Finger et al. 2013).

Results

The ratio of male to female participants was 0.97. The median age of participants was 65.5 years (IQR: 55.7–74.2), five participants were <18 years old. For minors, when necessary, parents or guardians served as proxies for the interview. The median acuity in the better eye for the sample was 0.54 logMAR (IQR: 0.38–0.85) and was 1.02 logMAR (IQR: 0.64–1.68) for the worse eye, a more detailed summary is given in Table 2.

Results of visual ability scores

Rasch analysis of AI difficulty ratings generates a single interval-scaled value for each person, the ‘person measure’, for which higher values correspond to higher levels of visual ability. The mean visual ability person measure across all participants was 0.17 logit (SD = 1.99). Table 2 provides a summary of these results, and the distribution of visual ability person measures for different age groups is shown in Fig. 1. A three-dimensional scatter plot of visual ability person measures as a function of logMAR acuity in the better eye and in the worse eye is shown in Fig. 2. The difference between visual ability person measures for different groups, defined by the VA in the better eye, was statistically significant, $F(2,131) = 39.57$, ($p < 0.001$; Bonferroni correction applied). Similar results for other factors are summarized in Table 2. For VI groups 1 and 2, the mean difference between visual ability person measures was 1.54 logits ($p < 0.001$); for groups 1 and 3, the mean difference was 3.30 logits ($p < 0.001$); and for groups 2 and 3, the mean difference was 1.76 logits ($p < 0.001$). There was a moderate negative correlation between logMAR acuity in the better seeing eye and visual ability person measures, $r(134) = -0.573$ ($p < 0.001$). This result shows that higher levels of VI given by acuity were associated with lower visual ability person measures.

Table 2. Demographic characteristics of the participants and descriptive statistics.

Variable	*N*	EQ-5D index mean [SD]	Visual ability (logits) mean [SD]	VA better (logMAR) median [IQR]	VA worse (logMAR) median [IQR]
Gender					
Male	66 [49%]	0.518 [0.281]	0.45 [2.03]	0.63 [0.31]	1.30 [0.84]
Female	68 [51%]	0.368 [0.322]	−0.09 [1.92]	0.75 [0.58]	1.24 [0.76]
p Value	–	0.005	0.11	0.77	0.73
Age (years)					
Below 40	10 [8%]	0.509 [0.297]	0.24 [1.38]	0.81 [0.56]	1.16 [0.78]
41–80	116 [86%]	0.433 [0.321]	0.22 [2.07]	0.69 [0.47]	1.25 [0.81]
Above 80	8 [6%]	0.491 [0.138]	−0.59 [1.02]	0.54 [0.26]	1.68 [0.72]
p Value	–	0.69	0.53	0.51	0.20
Level of VI better eye					
1	60 [45%]	0.596 [0.281]	1.34 [1.85]	0.37 [0.06]	0.88 [0.63]
2	50 [37%]	0.393 [0.270]	−0.20 [1.29]	0.69 [0.13]	1.27 [0.65]
3	24 [18%]	0.160 [0.220]	−1.96 [1.38]	1.50 [0.52]	2.26 [0.58]
p Value	–	<0.001	<0.001	<0.001	<0.001
Level of VI worse eye					
1	20 [15%]	0.669 [0.261]	1.85 [1.76]	0.35 [0.04]	0.40 [0.06]
2	46 [34%]	0.511 [0.301]	0.80 [1.63]	0.50 [0.15]	0.76 [0.15]
3	68 [51%]	0.329 [0.282]	−0.74 [1.79]	0.92 [0.55]	1.87 [0.69]
p Value	–	<0.001	<0.001	0.001	<0.001
Cause of VI					
DR	54 (40)	0.410 [0.309]	−0.26 [1.71]	0.74 [0.47]	1.33 [0.81]
Other RD	30 (22%)	0.421 [0.341]	0.57 [2.33]	0.66 [0.35]	1.32 [0.83]
AMD	15 (11%)	0.529 [0.296]	0.38 [1.83]	0.50 [0.26]	1.23 [0.74]
Glaucoma	10 (7%)	0.310 [0.258]	−0.53 [1.68]	0.66 [0.31]	1.32 [0.88]
Corneal disease	8 (6%)	0.490 [0.322]	0.15 [2.23]	0.58 [0.37]	1.25 [0.97]
Cortical/ON	13 (10%)	0.495 [0.299]	0.59 [2.27]	1.03 [0.81]	1.16 [0.81]
Cataract	4 (3%)	0.719 [0.162]	2.21 [1.21]	0.34 [0.04]	0.69 [0.34]
p Value	–	0.22	0.08	0.019	0.56
Number of comorbidities					
0–3	100 [75%]	0.479 [0.294]	0.28 [1.85]	0.68 [0.39]	1.28 [0.76]
3–6	34 [25%]	0.333 [0.334]	−0.13 [2.36]	0.73 [0.65]	1.37 [0.90]
p Value	–	0.017	0.30	0.31	0.85

DR = diabetic retinopathy; RD = Retinal disease; ON = optic nerve; AMD = Age-related macular degeneration.

Results for health states

The most commonly observed health state vectors for the EQ-5D-3L were [11111] (index of 1.000) and [22222] (index of 0.288), reported by 14 participants each. The 10 most common health state vectors are summarized in Table A2 in Appendix. The mean EQ-5D-3L index for the entire sample was 0.442 (SD = 0.311), comparisons between groups are given in Table 2. A 3-D scatter plot of the EQ-5D-3L index as a function of logMAR VA in the better eye and the number of comorbidities is shown in Fig. 3. The differences between EQ-5D-3L index for different VI groups, based on the acuity of the better eye, tested with anova, were statistically significant, $F(2,131) = 24.05$ ($p < 0.001$). *Post hoc* tests revealed that for VI groups 1 and 2 the mean difference was 0.203 ($p < 0.001$), for groups 1 and 3 the mean difference was 0.436 ($p < 0.001$), and the mean difference between groups 2 and 3 was 0.233 ($p = 0.001$). There was a moderate negative correlation between logMAR acuity in the better eye and EQ-5D-3L index, $r(134) = -0.506$ ($p < 0.001$). Higher values of logMAR (i.e. lower visual acuities) are associated with lower EQ-5D-3L index. A partial correlation between age (controlling for acuity in the better eye) and EQ-5D-3L index also was observed, $r(131) = -0.183$

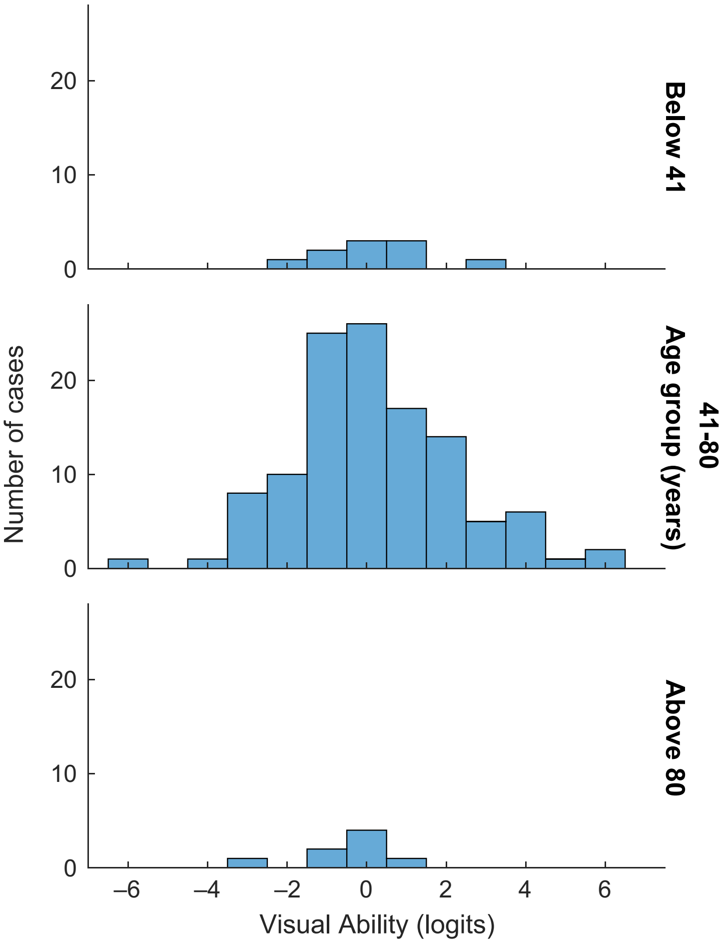

Fig. 1. Histogram showing the distribution of visual ability person measure per age group in the all sample.

(p = 0.035). The negative correlation indicates that the index tends to reduce with age.

Comparison between instruments

We observed a strong correlation between the EQ-5D-3L index and visual ability person measures, *r*(134) = 0.779 (p < 0.001).

Factors associated with visual ability person measures

Multiple linear regression analysis showed that gender, age, level of VI in the better eye and in the worse eye are significant independent predictors of visual ability person measures. Basic descriptive statistics and regression coefficients are summarized in Table 3; the four predictors account for 45% of the variance in visual ability person measures. Those with higher VA in the better eye have higher visual ability. The typical difference between VI groups (stratified by acuity in the better eye) was approximately 1.4 logits (unstandardized beta coefficients in Table 3). Level of VI in the worse eye does not achieve statistical significance in our model (p = 0.053).

Factors associated with EQ-5D-3L index

Multiple linear regression analysis showed that gender, level of VI in the better eye and number of comorbidities are significant independent predictors of EQ-5D-3L results. Basic descriptive statistics and regression coefficients are summarized in Table 4; the three predictors account for 36% of the variance in the EQ-5D-3L index. In agreement with the visual ability person measures, those with higher acuity in the better eye had shown higher EQ-5D-3L scores. The difference between sequential groups of VI would be approximately 0.2. Females and those with four or more comorbidities have lower EQ-5D-3L scores.

Figure 4 shows response patterns for the EQ-5D-3L domains when the group with 0–3 comorbidities was compared with the group with 4–6 comorbidities; the number of people with 'no problems' was reduced in all domains. With 4–6 comorbidities, the number of cases with some problems increased in D1 (mobility) and D4 (pain and discomfort). Also, with 4–6 comorbidities, there was an increased percentage of extreme problem for all but D1. The contrast is particularly visible in D3 (usual activities) and D5 (anxiety and depression).

Discussion

This study was conducted to determine which factors affect patient-reported measures of health utilities, estimated from EQ-5D-3L responses, and of visual ability, estimated from difficulty ratings of activity goals in the AI. Both measures were related positively to VI in the better eye. Regression analysis suggests that EQ-5D-3L utility index is associated with both, VI level in the better eye and the number of reported comorbidities. Visual ability measures are associated with age and VI in the better eye. Both utility and ability measures are associated with gender. These results are in agreement with the initial hypothesis that expected a different set of predictors for each of the two measures. However, contrary to initial expectations, results from both instruments were associated with VI in the better eye.

Our results indicate that the EQ-5D-3L index is responsive to visual impairments. In that sense, our results agree with previous observations by other investigators using the EQ-5D-3L (Langelaan et al. 2007; van Nispen et al. 2009) and other health utilities instruments (Crewe et al. 2011; Briesen et al. 2014). In contrast to our results, a study by Lloyd and colleagues found inconsistent associations of utilities with VA in patients with DR (Lloyd et al. 2008). Lloyd obtained lower scores for patients with acuity 6/12 to 6/18 than for patients with acuity 6/24 to 6/36. As suggested by Tosh et al. (2012), the association of EQ-5D-3L utility indices with visual impairments might depend on the visual disorder studied. However, our study included a range of disorder diagnoses and we found no evidence of disorder

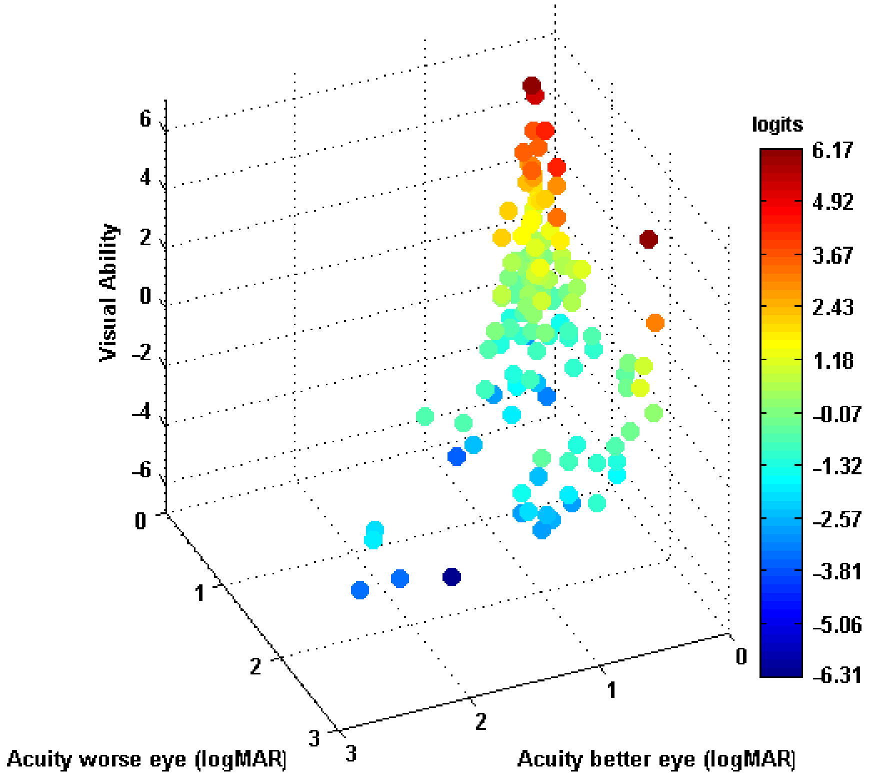

Fig. 2. Scatter plot showing the distribution of visual ability according with acuity in the better and worse eye.

diagnosis dependence. van Nispen et al. (2009) have found index results slightly higher than ours in an observational study applying the EQ-5D-3L in mixed causes of VI. Differences between our results and van Nispen's might be explained by the distribution of causes of VI, level of acuity in the better eye and age. The main cause of VI in their study was age-related macular degeneration, and in our study it was DR. Also, our IQR of acuities was wider and our participants overall were younger compared to the van Nispen et al. study (median age of 65 years for our study versus 78 years for their study). As reported by others, younger subjects with VI might feel, for example, more often anxious or depressed (Langelaan et al. 2007; van Nispen et al. 2016). As shown in Table A2 in Appendix, 19 of our participants reported 'severe depression or anxiety' that was never reported in the van Nispen et al. study's top ten health states. Another additional explanation for the difference between studies is that lower EQ-5D-3L utility indices are expected in Portugal than in the Netherlands because of differences in community calibrations. Ferreira and colleagues found that there is discrepancy between the EQ-5D-3L index in Portugal and other countries. Ferreira found mean absolute differences ranging from 0.090, compared with Spain, to 0.251, compared with the USA (Ferreira et al. 2014).

Gender and the numbers of comorbidities were predictors of the EQ-5D-3L index. The effect of gender that we found in our multiple regression is not commonly observed; however, Langelaan et al. (2007) did report significance of gender and that is in line with what has been found in the general population in some countries (Burström et al. 2001). Comorbidities also had an effect in the EQ-5D-3L; however, during the questionnaire administration clear instructions were given to consider difficulties caused only by VI. Generic questionnaires use broad questions and they are likely to capture effects of other health problems. Some studies have shown that people after stroke tend to report lower EQ-5D-3L scores than people with VI (Langelaan et al. 2007). In our case, sometimes these two conditions (VI and stroke) were present in the same participant. As shown in Fig. 4, there are noticeable changes in response patterns when comparing people with four or more comorbidities with people with three or less. The lack of control for type and number of comorbidities can be a problem when applying the EQ-5D-3L. Vision impairment has the potential to influence EQ-5D-3L responses only to four of the five domains: anxiety-depression, mobility, self-care and usual activities. Given the coarseness of the response scale, it is likely that vision impairment must be strong to affect the response. Effects of comorbidities combine with VI effects to produce the final response.

In agreement with previous studies, utility results were independent of the cause of VI and age (van Nispen et al. 2009; Crewe et al. 2011; Briesen et al. 2014). However, we observed a partial correlation (controlling to acuity in the better eye) between EQ-5D-3L index and age that pointed to some effect of age in this index. Langelaan and colleagues reported lower scores for people <41 years compared with people aged 41 years or older. They attributed their result to problems in social inclusion faced by young people with VI such as finding a job (Langelaan et al. 2007). Contrary to Langelann's explanation, we consider plausible that lower scores with increasing age would be due to unemployment or early retirement that increase difficulties in dealing with vision loss (Senra et al. 2011, 2015). Our results indicate that the EQ-5D-3L is an instrument that can be used to assess the impact of VI and to compute other important measures such as quality-adjusted life-years (QALY). However, its application requires caution because VI can affect domains that are not currently included in the questionnaire such as sleep quality or concentration (Flynn-Evans et al. 2014; Jelsma & Maart 2015).

Results of the AI provide a comprehensive assessment of the impact of VI. Our results for the AI are in agreement with what other authors found for patients with VI due to various causes (Pearce et al. 2011; Goldstein et al. 2014) or VI caused by specific eye diseases such as DR (Dunbar et al. 2012). The effect of age on visual ability obtained with the AI has been found before and has been explained by the overall physical functioning decline explained by aging (Goldstein et al.

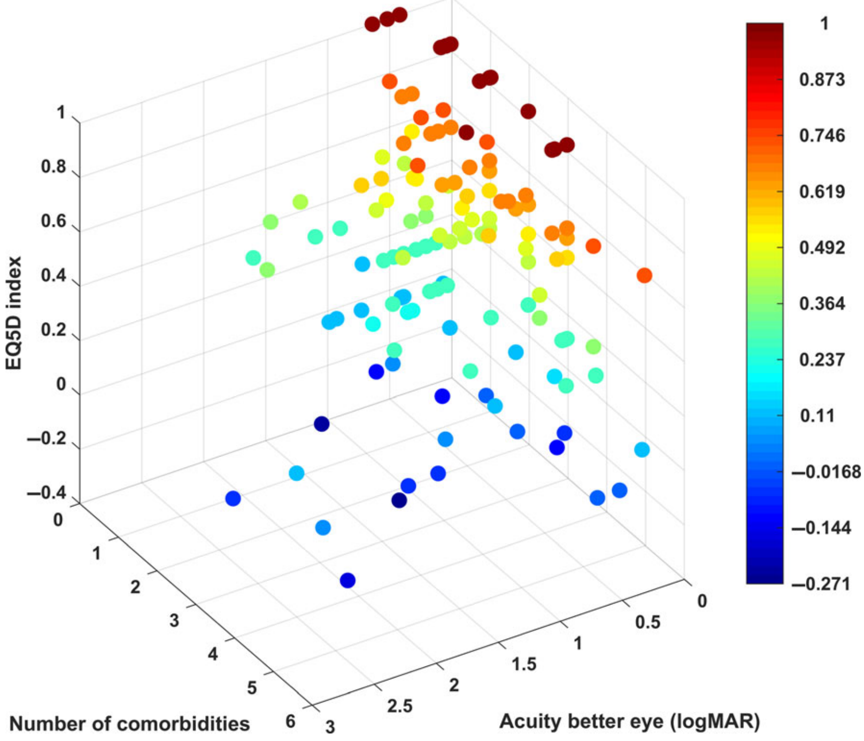

Fig. 3. Scatter plot showing the distribution of the EQ-5D index according with acuity in the better eye and number of comorbidities.

Table 4. Factors associated with EQ-5D index in a multivariate regression model with forward selection of variables.

Predictor	Un-standardized beta coefficients	p Value	Standard error
Intercept	0.726	<0.001	0.042
Gender			
Male*	–		
Female	−0.140	0.001	0.043
VI better eye			
1*	–		
2	−0.242	<0.001	0.048
3	−0.439	<0.001	0.060
Comorbidity			
0–3*	–		
3–6	−0.175	<0.001	0.050

* Reference category; excluded variables: age, level of VI worse eye; multiple *R*-squared: 0.38; adjusted *R*-squared: 0.36; *F*(4,129) = 20.01; p Value <0.001.

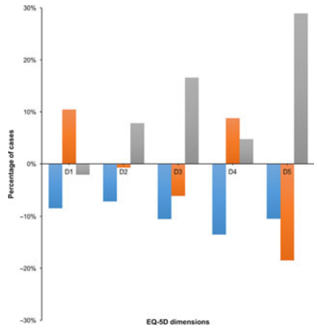

Fig. 4. Change in the percentage of participants reporting no problems (blue bars), some problems (orange bars) or extreme problems (grey bars) when comparing the group with 0–3 comorbidities with the group 4–6 comorbidities in each of the five domains of the EQ-5D. D1 (mobility); D2 (self-care); D3 (usual activities); D4 (pain and discomfort); D5 (anxiety and depression).

Table 3. Factors associated with visual ability scores (person measure) in a multivariate regression model with forward selection of variables.

Predictor	Un-standardized beta coefficients	p Value	Standard error
Intercept	1.978	<0.001	0.256
Gender			
Male*	–		
Female	−0.691	0.009	0.264
Age			
Below 80*	–		
Above 80	−1.495	0.010	0.576
VI better eye			
1*	–		
2	−1.397	<0.001	0.307
3	−2.940	<0.001	0.442
VI worse eye			
1*	–		
2[†]	–		
3	−0.622	0.053	0.318

* Reference category.

[†] Result collapsed with the reference category; excluded variables: comorbidities; multiple *R*-squared: 0.45; adjusted *R*-squared: 0.43; *F*(5,128) = 21.1; p-value <0.001.

2014). In addition, the sensitivity of the AI to the effect of VI in the worse eye is a further explanation why lower visual ability scores were obtained in the older group. Vision in the worse eye of participants with 81 years or older was typically very poor, range 0.8–2.7 logMAR, whilst for the other age groups was slightly higher, range 0.32–2.7 logMAR. It is understandable that when vision in one eye is reduced the visual field tends to be also compromised; severe VI in the second eye is likely to increase activity limitations such as mobility due to constriction of the visual field (Finger et al. 2013). This effect seems to be captured by our results because a detrimental effect of the level of VI in the worse eye in visual ability was only observed when VI in the worse eye was 3 (severe VI or blindness).

We acknowledge that a higher number of participants would have been ideal to have, for example, more subjects in the group with 81 years or more. Another advantage of a bigger sample would be a more detailed analysis by type of eye disease and type of comorbidity. A limitation that might reduce our explanatory power is that factors associated with scores do not follow a rectangular distribution.

To conclude, our results show that the EQ-5D-3L is useful when characterizing the burden of VI and, when necessary, to compute QALY associated with VI. Given the coarseness of the response scale of the EQ-5D-3L, the limited spectrum of domains assessed (Jelsma & Maart 2015) and the influence of comorbidities, it might be of limited use in vision rehabilitation (Malkin et al. 2013). Further studies are necessary to investigate whether the new versions of the instrument are able to improve these limitations.

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Appendix

Table A1. List of comorbidities used for the interview.

1. Cancer
2. Diabetes
3. Heart condition
4. Hypertension
5. Musculoskeletal disorder
6. Pulmonary disease
7. Stroke or brain haemorrhage
8. Hearing impairments
9. Thyroid condition
10. Psychological problems
11. Neurologic problems
12. Chronic allergies
13. Gastrointestinal condition
14. Liver disease
15. Autoimmune diseases
16. Endocrine condition

Table A2. Most frequently reported health states.

Health state	EQ-5D index	No. of participants	Percentage
11111	1.000	14	10
22222	0.288	14	10
22223	0.129	10	7
21223	0.287	9	7
11112	0.767	7	5
11121	0.694	7	5
21222	0.446	7	5
21221	0.482	6	4
11122	0.657	5	4
21111	0.695	5	4

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