The Impact of Visual Impairment on Functional Vision of Children in Rural South India: The Kariapatti Pediatric Eye Evaluation Project

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Purpose. To determine the impact of visual impairment on functional vision of children in a rural population of south India.

Methods. A visual function questionnaire (LVP-VFQ) was administered to 1194 children aged 7 to 15 years identified through a systematic random sampling technique from 144 hamlets of Kariapatti in rural south India as part of a larger population-based project. Visual acuity estimations and clinical examinations for morbidity were performed in these 1194 children. A Rasch analysis was performed to validate the use of the instrument in this population. Bootstrap estimates (95% confidence intervals) of the regression coefficients were used to compare visual function scores between children with normal sight and children with uncorrected monocular and binocular visual impairment.

Results. The mean age of children was 10.3 ± 2.1 years. The reliability estimates were 0.82 for person ability and 0.88 for item difficulty parameters, according to the Rasch analysis. A separation index of 2.15 was obtained for person measures and 2.74 for item measures, and the mean square infit and outfit statistics were 1.03 (Z_{STD} 0.1) and 0.99 (Z_{STD} −0.1), respectively. Children with monocular visual impairment (bootstrap estimate [95%CI] −0.05 [−0.08 to −0.01]) and binocular visual impairment (bootstrap estimate [95%CI] −0.09 [−0.11 to −0.07]) were more likely to have functional visual deficits than were normally sighted peers.

Conclusions. Monocular or binocular visual impairment impacts on the functional vision of children in this rural population. Further studies are needed to determine the impact of treatment of visual impairment on functional vision in children of this population. (*Invest Ophthalmol Vis Sci.* 2004;45: 3442–3445) DOI:10.1167/iovs.04-0233

A large proportion—approximately 41%—of the over 1 billion population of India is aged younger than 16 years.[1] The prevalence of blindness among children in India is reported to be five times that reported in other developed countries, with an estimated 210,000 children blind.[2–5] Blindness and visual impairment in children is now recognized as a priority by blindness control programs including VISION 2020—The Right to Sight initiative.[6] A better understanding of the burden of childhood blindness and ocular morbidity in children is essential for planning effective control measures. We have reported the magnitude of childhood blindness and visual impairment, and the distribution of ocular morbidity among children in this population.[5] Identifying visual impairment in children is difficult particularly at younger ages due to multiple reasons, including the ability of the child to comprehend the testing procedure and the ability of the child to cooperate with the testing procedure.[7,8] An additional issue to consider is the sensitivity, specificity, and predictive values of different tests and results obtained after screening by different cadres of personnel. There are reports of less than optimal rates for identification of visual impairment at different age groups, even when screening was performed by trained paramedics including optometrists.[7,8] We have previously reported the predictive values using community workers to identify visual impairment and ocular morbidity.[5]

We explored the impact of visual impairment on functional vision of children and the correlation between functional abilities and vision in a community setting as part of a population-based assessment of pediatric eye care services. To the best of our knowledge, there have been no previous population-based assessments of the impact of visual impairment on functional domains of children in India.

Methods

The Kariapatti Pediatric Eye Evaluation Project (KPEEP) is a population-based project primarily designed to determine appropriate service delivery models for eye care services targeting children in rural communities of south India. We have published details of the methodology of the project and baseline estimates of the magnitude of disease in this population.[5] To summarize, we chose the Kariapatti block of Virudhanagar district in the state of Tamil Nadu in south India as the project area. Baseline estimates for magnitude of eye diseases were obtained from children who were aged 0 to 15 years and were full-time residents of the project area. Community workers trained in the measurement of visual acuity using Cambridge crowded cards[9] estimated vision for children chosen for this substudy. Community workers also performed a basic ocular examination using a torch light to look for external ocular abnormalities. All children with visual or ocular abnormalities identified by the community worker were subjected to comprehensive ocular examinations by a team led by a pediatric ophthalmologist that included an optometrist, an ophthalmic nurse, and a counselor. These exams included vision measurements and refraction

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TABLE 1. The LVP-Functional Vision Questionnaire

1. Do you have any difficulty in making out whether you are seeing a boy or a girl from across the road in the day?
2. Do you have any difficulty in seeing whether somebody is calling you by waving his hand from across the road?
3. Do you have any difficulty in copying from the blackboard sitting in the first bench of your class?
4. Do you difficulty in reading the bus numbers?
5. Do you have any difficulty in reading the other details on the bus (like the place where it is going)?
6. Do you have any difficulty in reading your textbooks at an arm's length?
7. Do you have any difficulty in writing along a straight line?
8. Do you have any difficulty in threading a needle?
9. How much difficulty do you have in finding out the difference between 1 rupee and 2 rupee coins (without touching)?
10. Do you have difficulty in locating the food on your plate while eating?
11. Do you have difficulty in identifying colors (e.g., while coloring)?

The questionnaire used a 5-point scale: 0 "no difficulty," 1 "a little difficulty," 2 "a moderate amount of difficulty," 3 "great deal of difficulty," and 4 "unable to do the activity."

including cycloplegic refraction, slit lamp biomicroscopy for anterior segment, and dilated posterior segment examinations.

The study was approved by the Institutional Review Board/Ethical Committee of the Aravind Eye Care System, Madurai, India, and adhered to the tenets of the Declaration of Helsinki. We obtained verbal informed consent for the study at three different levels: community, household, and school. At the community level, we explained the study to the village leaders and at community meetings arranged for this purpose. At the household level, we explained the study to the parents or caretakers of children and obtained their consent for examination and interviews. At the school, we explained the study to the head of the school and to the teachers and obtained their consent for examinations and interviews of children. Obtaining written informed consent was problematic, because a significant proportion of this population was illiterate and had had bad experiences with placing signatures on written documents that they could not read.

We used a previously validated questionnaire (LVP-VFQ) to measure functional visual performance among children aged 7 years or older in this population.[10] Details of the development, content, and psychometric properties of this questionnaire have been published.[10] The visual function score was based on responses to 11 questions with each question answered using a 5-point scale ranging from a score of 0 indicating "no difficulty at all" to a score of 4 indicating "unable to perform the activity" (Table 1). We asked an additional question "How do you think your vision is compared to your normally sighted friend: Do you think your vision is as good as your friend, a little bit worse than your friend, much worse than your friend?" relating to self assessment of a subjects' vision in comparison to their normally sighted peers.

Considering that the initial use of the LVP-VFQ was validated in a hospital setting, we decided to repeat validation of the instrument before its administration in the community. We piloted the administration of the questionnaire to a group of 100 randomly chosen school-attending children aged 7 to 15 years that included a mix of normally sighted and visually impaired children chosen from within villages of the study area. We performed a Rasch analysis (student version of Winsteps, ver 3.33; Mesa Press, Chicago, IL) using an unconditional maximum likelihood estimation routine on the matrix of ratings obtained in the pilot study to estimate interval measures of perceived visual ability for functional visual performance. The ratio of the adjusted standard deviation to the observed standard deviation of the person or item measure distribution is the reliability coefficient, which is the fraction of variability in the observed measurement distribution that can be attributed to the true variance of the person or item measure. The adjusted standard deviation is the square root of the difference between the observed variance and the square of the standard error (SE^2). The closer reliability is to 1.0, the less variability in the measurement distribution can be attributed to measurement error. We obtained reliability estimates of 0.82 for person ability and 0.88 for item difficulty parameters. We tested for the content validity using the separation index, which is a measure of the distribution of parameters across the visual ability dimensions and is the ratio of the estimated true standard deviation to the standard error of the estimate. We obtained a separation index of 2.15 for person measures and 2.74 for the item measures. We evaluated construct validity using the infit and outfit statistics. The mean square (MNSQ) infit and outfit statistics should ideally be 1.0. Values substantially less than 1.0 indicate dependency or predictability of the data, whereas values substantially greater than 1.0 indicate noise in the data or the presence of outliers. The MNSQ infit statistic across all items was 1.03, with a Z_{STD} of 0.1, and the MNSQ outfit statistic across all items was 0.99, with a Z_{STD} of -0.1, suggesting there was not any gross misfit of items.

After validation of the questionnaire in a population-based setting, we administered it to 10% of children aged 7 to 15 years and attending school in the 144 hamlets of the Kariapatti block. The sampling frame consisted of 12,506 children who were aged 7 to 15 years and attending school. We used a systematic random sampling technique to identify 10% of these children for assessment of functional visual performance in the main study. A trained community worker (SB) administered the questionnaire to the children in a face-to-face setting with a teacher present in the same room but seated at a distance, so that the teacher could not influence or suggest responses. Interviews were conducted before all ocular examinations including vision estimation, and the community worker was masked to the findings of the functional vision assessment. We used presenting vision measures for assessing the impact of visual impairment on functional vision, as functional vision is a measure of presenting rather than best corrected acuity. We categorized presenting visual acuity as better than or equal to 20/40 and worse than 20/40. A child was considered to be normally sighted if the presenting vision in both eyes was better than or equal to 20/40. A child was considered to have monocular visual impairment if the presenting vision in the better eye was better than or equal to 20/40 and the presenting vision in the worse eye was worse than 20/40. A child was considered to have binocular visual impairment if the presenting vision was worse than 20/40 in both eyes.

Item responses were grouped into three main domains: distance vision (questions 1–5), near vision (questions 6–8), and sensory adaptation (questions 9–11). We calculated a total score for each of the questions and subscales. We expressed this score as a percentage of the total possible score ranging from 0 to 100, with higher scores indicating better results.

We performed further statistical analysis on computer (Stata, ver. 8.0; Stata, College Station, TX), to explore the association of monocular and binocular visual impairment on functional vision. We used presenting acuity in the better eye as a measure of the vision used in daily life and modeled presenting acuity as a categorical variable using a presenting acuity of 20/40 as the cutoff for visual impairment. We considered age and sex of the child as potential confounders and adjusted for these variables in the multivariate regression analyses. We modeled age as a continuous variable, and sex was modeled as a categorical variable. We explored the influence of monocular visual impairment and bilateral visual impairment on functional vision domains by comparing participants with either monocular impairment or bilateral impairment with those participants who had presenting visual acuity better than or equal to 20/40 in both eyes.

While examining the fit of regression models, we found residuals that were independent but not distributed in a Gaussian pattern. This could be attributed to the skewed nature (toward higher scores) of the distribution of visual function scores. We used a nonparametric bootstrap estimate to calculate regression coefficient estimates, taking into

account the non-Gaussian distribution of residuals. Estimates from the models were calculated and repeated 1000 times to create bootstrap estimates and 95% bias-corrected confidence intervals (CI) were calculated for the bootstrap estimates.

Results

We administered the LVP-VFQ to 1194 (95.50%) of 1250 children chosen randomly. The questionnaire could not be administered to the remaining 54 children because they were temporarily out of station. The mean age of the children was 10.31 ± 2.08 years (median, 10.00; range, 7–15), and 577 (48.32%) were girls. The mean time of administration of the LVP-VFQ was 10.5 ± 2.1 minutes. The prevalence of visual impairment was 9.21% (95% CI: 7.57–10.85). None of these children had been advised to use any refractive correction, including spectacles. Monocular visual impairment (presenting visual acuity worse than or equal to 20/40 in the worse eye and better than 20/40 in the better eye) was present in 48 (4.02%) children and binocular visual impairment (presenting vision worse than or equal to 20/40) was present in an additional 62 (5.12%) children.

We adjusted for presenting visual acuity in the better eye (because presenting vision in the better eye can influence visual function domains) while modeling for the impact of monocular impairment on visual function domains. There was a significant reduction of visual function associated with monocular visual impairment after adjusting for age and sex (bootstrap regression coefficient [95% bias-corrected CI] −0.05 [−0.08 to −0.01]) compared with children with normal vision. On further exploration of the association of monocular vision with the functional domains, monocular visual impairment remained significantly associated only with the domain relating to near visual function (Table 2). Binocular visual impairment was associated reduction of scores across all domains of visual function (Table 2).

Presenting visual acuity in the better eye correlated strongly with total visual function scores (Spearman's $\rho = -0.40$) and with visual impairment in any eye (Spearman's $\rho = -0.42$). We explored the relationship between visual acuity and the perception of each child regarding his or her vision in comparison to normally sighted friends (Table 3). Children with binocular visual impairment were more likely to state that they had visual acuity worse than their normally sighted friends ($P < 0.05$). More than 60% of children with monocular visual impairment stated they could see as well as their normally sighted friends. We could not determine the association of ocular morbidity with visual function domains, because the number of children with ocular morbidity was too small in our sample to make any meaningful analysis.

Table 2. Vision Function Scores of Children with Visual Impairment Compared with Children with Normal Vision, Adjusted for Age and Sex

	Monocular Visual Impairment	Binocular Visual Impairment
Distance	−0.03 (−0.06 to 0.00)	−0.08 (−0.09 to −0.06)
Near	−0.04 (−0.07 to −0.02)	−0.06 (−0.08 to −0.05)
Sensory	−0.05 (−0.11 to 0.02)	−0.08 (−0.10 to −0.06)
Overall score	−0.05 (−0.08 to −0.01)	−0.09 (−0.11 to −0.07)

Data are bootstrap estimates of regression coefficients with bias-corrected 95% CI (in parentheses) relative to children with normal vision in both eyes. The model for monocular visual impairment was additionally adjusted for presenting vision in the better eye besides age and sex of the child.

Table 3. Self-Reported Assessment of Vision of 1194 Children in the Study Population

	Normal Vision	Monocular Impairment	Binocular Impairment
As good as friend	1012 (93.36)	30 (62.50)	24 (38.71)
A little worse than friend	68 (6.27)	16 (33.33)	24 (38.71)
A lot worse than friend	4 (0.37)	2 (4.17)	14 (22.58)
Total	1084	48	62

Data are number of subjects, with percentage of total group in parentheses.

Discussion

We found a significant reduction of visual function based on responses to the questionnaire for children with monocular or binocular visual impairment compared with their normally sighted peers. Although scores were significantly reduced across all domains in children with binocular impairment, a significant reduction was found only for the domain relating to near vision for children with monocular impairment. We find it interesting that the association with functions relating to near work persisted, even after adjusting for presenting vision in the better eye, age, and sex of the children. It may be that near work is especially important for children or an especially sensitive index of their overall visual function. However, we are unable to validate these conclusions, because our study was not designed to explore these possibilities, which would require actual observations of children performing activities of near work over a period and determination of the amount of near work a child may perform during the course of several days.

It is debatable whether we can use the visual function questionnaire in isolation to detect children with visual impairment. Although the results of the Rasch analysis indicate that the questionnaire provides valid and reliable data even when used within a rural community setting, we advise caution on the use of the visual function in isolation. The questionnaire is a subjective measure, and children may under- or overestimate the level of difficulty they have with a particular function.[11] Although the questionnaire could be made more objective by having children actually perform the tasks in presence of the investigator,[12] this would introduce a level of complexity that would negate the very purpose of using the questionnaire as a screening tool. It has been reported in an adult population that a visual function questionnaire, in isolation, did not help determine the appropriateness of cataract surgery, as visual function score does not fully reflect visual impairment.[13] We found that nearly two thirds of children with monocular visual impairment and 39% of children with binocular visual impairment perceived themselves to have vision equivalent to their normally sighted peers, even in the presence of some functional impairment, suggesting that a comparison of vision with normally sighted peers without objective measures of vision or visual function does not aid identification of children with visual impairment.

Our study was a cross-sectional study, and hence the reduced scores we report are based on comparisons of children with normal sight and children with visual impairment. These results do not indicate a longitudinal shift in the visual function with a change in vision or disease status. The population-based design, random selection of subjects, and high response rates can be considered as strengths of the study. Further studies are needed to determine whether the visual function questionnaire can document functional improvements after treatment for visual impairment in children.

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