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Working Paper

Young Lives

Does Visual Acuity Have an Effect on Children's Educational Achievement?

Evidence from Peru

Santiago Cueto, Javier Escobal, Juan León and Mary E. Penny

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Young Lives, Oxford Department of International Development (ODID), University of Oxford, Queen Elizabeth House, 3 Mansfield Road, Oxford OX1 3TB, UK

Tel: +44 (0)1865 281751 • Email: younglives@younglives.org.uk

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The authors

Santiago Cueto holds a degree in Educational Psychology from the Pontifical Catholic University of Peru and a PhD in the same field from Indiana University, United States. He has been a Visiting Researcher at the University of California at Davis and the University of Oxford. Santiago is the Research Director and Senior Researcher at GRADE, where he coordinates the Peru component of the international study Young Lives/Niños del Milenio. He has worked as a consultant to international organisations such as the Inter-American Development Bank, the World Bank and UNESCO.

Javier Escobal has a PhD in Economic Development from the Wageningen University in Holland and an MA from New York University. He is a Senior Researcher at GRADE. He is also a member of the Board of Directors of the Central Reserve Bank of Peru; member of the Fiscal Committee, an independent board under the Ministry of Economy and Finance (MEF); member of the Advisory Committee of the Ministry of Development and Social Inclusion (MIDIS); member of the Advisory Committee for Estimating Poverty (INEI); and member of the specialised advisory group for the National Council of Competitiveness and Formalization.

Juan León has a PhD in Educational Theory and Policy and Comparative and International Education from Pennsylvania State University, United States. He has a Bachelor's degree in Economics and a diploma in Liberal Arts from the Pontificia Universidad Catolica of Peru. Juan is an Associate Researcher at GRADE in Peru. He is also a Lecturer in the Department of Psychology at the Universidad Antonio Ruiz de Montoya in Lima.

Mary Penny is a British physician, trained at Girton College, Cambridge and Birmingham University Medical School. She worked for seven years in the British National Health Service before being awarded a Wellcome Trust scholarship in 1984 to study the microflora of the small intestine in diarrhoea at the Instituto de Investigación Nutricional (IIN) in Peru. She returned to Peru in 1989 and has remained since. She is the Principal Investigator for Young Lives in the IIN, responsible for the health and nutrition aspects of the project in Peru. She is the director of the IIN and also runs other projects, mainly in relation to child health and nutrition, improving health services and conducting clinical trials.

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Summary

Inequity is an important issue for many international initiatives, including the current Sustainable Development Goals (SDGs). One aspect of inequity that has received little attention is the impact of disability on education. This working paper explores whether mild or moderate levels of visual impairment are associated with educational performance for 7 and 8-year-old children in Peru. Descriptive statistics from the Young Lives sample suggested that children with poorer visual acuity have better performance in mathematics, reading and vocabulary tests. However, when several characteristics of the children and their families are included as controls, the results reverse, and we found a significant negative effect of poor visual acuity on mathematics tests, marginally significant for vocabulary, and not significant for reading.

We also explored the impact for different groups of children and whether the results changed if we used categories of mild and moderate visual impairment instead of a continuous variable. We found that even marginally reduced visual acuity, just below 20/20, is associated with a lower performance in mathematics. The results outlined in this paper, along with other research in the field, support the visual screening of all schoolchildren. The final section of the paper discusses the results and policy options, including the participation of teachers in screening children for visual impairment.

1. Introduction

Education has been considered a human right for everyone for over 65 years (United Nations 1949), yet many children around the world do not attend schools or if they do, show very poor levels of learning. Internationally, poverty, ethnicity, rural residence, gender and disability are among the more frequent characteristics of children that may prevent their enrolment in school, completing basic education or achieving at expected levels of performance in standardised tests (UNESCO 2016). This working paper focuses on disability, specifically visual impairment. The paper aims to analyse whether primary school children with even minor reductions in visual acuity (defined below) also show lower levels of educational performance.

Disability is a topic that has received little attention from public policy and research, in spite of the generally poor levels of access and achievement of disabled populations. Given that it is an important source of inequality, disability has been included as one of the variables in the Sustainable Development Goals (SDGs), specifically Goal 4, which refers to education, proposed by United Nations and adopted by many countries for the period 2015-2030 (United Nations 2017).

The World Health Organization (WHO) definition is that:

> 'Disabilities is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations.' (WHO 2017)

In 2011, WHO and the World Bank published a World Report on Disabilities. They estimated that around 15 per cent of the world´s population show some form of disability, which is higher than the prevalence identified a few decades before. They also found that poor countries are more likely to show higher rates of people with disabilities, especially women and older people. Finally, they found that people with disabilities show poorer educational indicators, compared to their peers with no disability. In 2006, the UN approved the Convention on the Rights of Persons with Disabilities, which has been endorsed by most countries.[1] This includes an article on education (Article 24), which supports an inclusive education model that should seek equal opportunities for all children.

Peruvian laws and regulations also include the right of people with disabilities to quality education. For example, the General Law of Education (#28044) from 2003 promotes the incorporation of groups that have been excluded, marginalised and vulnerable. More specifically, the Law for Persons with Disabilities of 2012 (# 29973) promotes the right to education and equal opportunities for this group. However, according to three Ombudsman reports, children with disabilities often do not attend school or, if they do, attend a special education school, which is considered a form of segregation. The challenges for high-quality education for students with disabilities are related to inadequate infrastructure, insufficient number of professionals specialised in inclusive education, insufficient specialised materials, and poor sensitivity of communities towards the full inclusion of students with disabilities

1 Available at www.un.org/disabilities/documents/convention/convention_accessible_pdf.pdf.

(Defensoría del Pueblo 2001; 2007; 2011). Cueto, Miranda and Vásquez (2016) show that in Peru, a country where inequality is prevalent, there is very little research on disability and education. The National Institute of Statistics has estimated that around 5.2 per cent of the population show some form of disability (INEI 2014). Between the ages of 5 and 19, an estimated 47 per cent of children with disabilities do not attend schools.

Included among the disabilities that could affect educational performance are sensory disabilities, including visual impairment. Visual impairment can interfere with how information is perceived and processed by the brain, and the level of connectedness of the child, thus interfering with school progress and learning. In a review, Basch (2011) pointed out that: 'Symptoms of visual problems that threaten educational achievement include frequent eye rubbing or blinking, short attention span, avoidance of reading and other close activities, frequent headaches, covering of 1 eye, tilting the head to 1 side, holding reading materials close to the face, eyes turning in or out, seeing double, losing place when reading, and difficulty remembering what has been read' (Basch 2011: 601). In another review, Thurston (2014) found that there is a significant correlation between visual impairment and reading development for primary school students.

In regards to prevalence of visual problems, Stevens et al. (2013) performed a systematic review of studies of moderate and severe vision impairment (MSVI, i.e. visual acuity of between 6/18 and 3/60) and blindness (i.e. visual acuity below 3/60). They estimated that around 32.4 million people worldwide were blind (0.5 per cent of the global population) and 191 million people showed MSVI (2.8% of the global population). There was a tendency for higher prevalence of both blindness and MSVI in developing regions. Women were more likely to show visual impairment than men. Bourne et al. (2013) found that 65 per cent of people with blindness and 76 per cent of people with MSVI had a preventable or treatable cause. Leasher et al. (2013) estimated the prevalence of vision loss in Latin America and the Caribbean. In their systematic review, they found that 0.4 per cent of the population was blind, while 2.7 per cent showed MSVI. They estimated that for the whole region, approximately 2.3 million people are blind and 14.1 million have MSVI. However, they also reported a reduction in the prevalence of both conditions between 1990 and 2010. The main reasons for blindness were cataract and macular degeneration. For MSVI, the main reasons were related to uncorrected refractive error. A refractive error refers to the inability to clearly focus on images, which results in blurred vision. The most common refractive errors are myopia, hyperopia, astigmatism, and presbyopia. Refractive errors can be treated with corrective glasses, eye lenses or surgery. Other causes for MSVI are cataract and macular degeneration (Bourne et al. 2013), although these are more likely to appear at older ages.

There have been a few studies on visual acuity and educational performance. Several include a study of the association between these, with mixed results. In Brazil, Gomes-Neto et al. (1997) found that poor visual acuity was associated with the probability of dropping out, delayed grade progression, and poor achievement (reading and mathematics) in primary school students. For 4 and 5-year-old children in the UK, Bruce et al. (2016) found that visual acuity was positively related with results in a literacy test. In a study in Israel, Goldstand, Koslowe and Parush (2005) found that visual acuity was positively related with proficiency in reading for seventh graders. In Ethiopia, for children aged 7 to 13 years old, Poppe (2014) found that poor visual acuity was related with a higher probability of dropping out, but only for girls; it was not related to grade repetition, but it was associated with poor writing skills for girls and reading skills for boys. The association with cognitive skills and mathematics was not significant.

However, some studies have found no association or even a negative association between visual impairment and educational achievement. For example, in the USA Mutti et al. (2002) found that children with myopia spent more time studying and reading for pleasure, and scored higher on a reading and language test. Similarly, in China Hannum and Zhang (2012) found that primary school students from higher socio-economic backgrounds and higher levels of achievement were more likely to show visual acuity problems. In Singapore, Dirani et al. (2010) found that there was no association for Grade 4 students between visual acuity and grades obtained in a national test of reading in mother tongue, English, and mathematics. The reason why some higher achieving children may also show lower visual acuity is that they may be engaged in more 'near work' activities, such as reading, which would have a negative effect on visual acuity but a positive effect on performance (this is referred to as the 'use-abuse theory'; Angle and Wissman 1980). Recent studies, however, have found no association between time spent on near activities and myopia (Lu et al. 2009).

There have also been a few intervention studies. Hannum and Zhang (2012) found that providing glasses resulted in improvements in mathematics and literacy tests, but not language tests. In the only experimental study that we have been able to identify, Glewwe, Park and Zhao (2016), randomly assigned glasses to primary school students in China. They found that providing the children with glasses increased achievement (combined score of Chinese, mathematics and science) by at least 0.16 standard deviations after one year. They also found that the effects were greater for students with lower prior performance. They estimate that this intervention is very cost-effective.

The literature review above suggests that visual impairment may be a significant issue for school achievement, on which there is still very little research available, especially from developing countries, where school performance is low. This working paper adds to this literature, providing estimates of the association between visual acuity and achievement in measures of receptive vocabulary, reading and mathematics for primary school-aged schoolchildren in Peru.

2. Methodology

2.1 Sample

The data used in this paper come from Young Lives, a longitudinal study of childhood poverty in Ethiopia, India (in the states of Andhra Pradesh and Telangana), Peru and Vietnam. The study includes two cohorts: one born around 1994 (the Older Cohort) and the other in 2001 (Younger Cohort). Young Lives collects information from children and their families at their homes. So far, five rounds have been collected (in 2002, 2006, 2009, 2012 and 2016). In this study, we concentrate on the Younger Cohort and on the Peru data from the Round 3, which is the only one that includes data on visual acuity.[2] The sample in Peru was selected randomly from 20 sites around the country, excluding the richest 5 per cent of districts (Escobal and Flores 2008). Originally, the sample had 2,052 children. By Round 3, we were unable to follow up with 4.4 per cent of the children in the Younger Cohort for a variety of reasons, resulting in a sample of 1,943 children (Cueto et al. 2011). From these, we have

2 More information about Young Lives is available at http://younglives.org.uk/content/about-us.

included all children who have measures for visual acuity, control variables and outcomes, resulting in 1,724 children in the analyses below (although there are variations on sample size depending on the specific variable under analysis). Table 1 presents the characteristics of this analytical sample. We include a comparison of the included and excluded children (Appendix 1) in order to assess whether there may be bias between these two groups. The results show a few significant differences, as children who are included are more likely to be at the correct age for grade at school, and have slightly higher scores in the vocabulary (PPVT) test, but have less educated mothers and lower scores on the reading test (EGRA test). There are no differences in wealth, sex, age, maternal tongue, area of residence, and scores in mathematics.

2.2 Measures and procedures

For testing visual acuity, we used the Snellen Chart. This consists of 11 lines of letters. The first line has a single letter, which is largest. The following lines include an increasing number of letters, of diminishing size. For the fieldwork, the chart was taped on a wall at the child's home. Children were tested between 8 am and 5 pm, with sufficient natural light, at a distance of 6 metres measured with a cord. Each child was asked to read the lines from the top, going down each line with one eye while covering the other, before repeating the procedure with the other eye. Hence, the results can be presented for the better eye and worse eye. If the child had a result lower than 20/40, it was recommended that the parent to the child to visit an ophthalmologist. If the child wore glasses, the procedure should have been repeated with and without glasses. In order to use the results as a continuous variable, we transformed the Snellen scale into a Log MAR scale, which is a logarithmic transformation of the results from the Snellen Chart, using the formula suggested by Bailey-Lovie (SPIE 2017):

$$LA = \log_{10}\left(\frac{1}{S}\right) \qquad e.g., LA = \log_{10}\left(\frac{1}{20/40}\right) = 0.3$$

Higher results indicate lower visual acuity.

We administered three tests for achievement. The first was the Peabody Picture Vocabulary Test (PPVT) in Spanish (Dunn, Padilla, Lugo and Dunn 1986). The test consists of 125 items of increasing difficulty. For each item, the child is shown four figures, while the field worker reads a word. The child is expected to point to the figure that corresponds to the word read, or else say the number underneath it. For the analysis we used the raw score (i.e. number of correct words, according to rules from the test on where to start given a child´s age, and when to stop administering the test due to repeated errors). To test for reading skills, we adapted the Early Grade Reading Assessment (EGRA), developed by USAID and RTI, aimed at the first grades in primary schools. We used four subtests of the EGRA: familiar word identification (the number of words identified in one minute); word fluency (the number of words read in one minute); listening comprehension (the number of correct answers to questions based on a text read to the children); and reading comprehension (the number of correct answers to questions based on the text). We calculated a global score for EGRA using these four scores. We used factor analysis with a principal component factor as method of extraction. The resulting factor explained 64 per cent of the common variance among the four variables. In the field however, there was a rule to discontinue the EGRA after the first two subtests, if the child could not read beyond word identification and fluency. This resulted in losing data for 229 children, who only had data for the first two subtests. To recover this data, we imputed scores for children with incomplete EGRA tests. The procedure was based on a regression using scores from Round 2 of Young Lives, including the PPVT and the test of quantitative notions (called CDA)[3], plus measures of location (three regions in the country), and whether the child lived in an urban or rural environment. This procedure resulted in a distribution that was very similar to the distribution before imputation. For mathematics, a test was developed with 29 items, including knowledge of numbers and problem solving, and measuring number and number sense abilities.

For PPVT and EGRA we only included children who preferred to answer in Spanish, excluding all children who responded in an indigenous language (i.e. Quechua). For mathematics, we included all children, given that the questions were based on numbers and when text was included, it was adapted to the child's language. Young Lives performed a pilot of all these tests and performed a psychometric analysis of the results from Round 3, showing acceptable levels of reliability and validity for the three tests.[4]

The tests and surveys mentioned above were administered at home. The household survey gathered demographic information about the children and his/her family that was used in the different analyses performed. All procedures were approved by the Ethics Committees at the University of Oxford and the Instituto de Investigación Nutricional (one of the Young Lives partners in Peru).

With regard to the multivariate analysis, in order to estimate the relationship between visual acuity and child´s achievement, we used Ordinary Least Squares (Greene 2003). This statistical technique allows estimating the relationship, holding constant different variables that the published literature suggests are associated with our dependent variables. We included as control variables sex (female), age (in months), maternal education (divided into complete secondary or more and incomplete secondary or less), family wealth in Round 3 of Young Lives (a factor score that includes measures of housing quality, access to services, and consumer durables), area of residence (urban), and maternal tongue (indigenous). Thus, the model estimated is:

$$\begin{aligned} \text{EGRA}_j &= \alpha_o + \alpha 1\text{Visual Acuity}_j + \alpha_2\text{Female}_j + \alpha_3\text{Age}_j + \alpha 4\text{Maternal education}_j \\ &\quad + \alpha_5\text{Family Wealth}_j + \alpha_6\text{Urban}_j + \alpha_7\text{Indigenous}_j + \varepsilon_j \qquad \varepsilon_j \sim N(0, \sigma^2) \\ \text{PPVT}_j &= \alpha_o + \alpha 1\text{Visual Acuity}_j + \alpha_2\text{Female}_j + \alpha_3\text{Age}_j + \alpha 4\text{Maternal education}_j \\ &\quad + \alpha_5\text{Family Wealth}_j + \alpha_6\text{Urban}_j + \alpha_7\text{Indigenous}_j + \varepsilon_j \qquad \varepsilon_j \sim N(0, \sigma^2) \\ \text{Math}_j &= \alpha_o + \alpha 1\text{Visual Acuity}_j + \alpha_2\text{Female}_j + \alpha_3\text{Age}_j + \alpha 4\text{Maternal education}_j \\ &\quad + \alpha_5\text{Family Wealth}_j + \alpha_6\text{Urban}_j + \alpha_7\text{Indigenous}_j + \varepsilon_j \qquad \varepsilon_j \sim N(0, \sigma^2) \end{aligned}$$

The coefficients estimated (α_1) for the different dependent variables in our analysis (EGRA, PPVT and maths) estimate whether the association between visual acuity and our dependent variables is statistically significant; they do not indicate causality between them. In addition, in order to estimate possible heterogeneous effects of visual acuity on child´s achievement, we estimated the models presented above for different sub-populations (see below).

Finally, we considered including overage (i.e. being in a grade behind the normative age; in Peru children should be 6 years old to enrol in first grade) as a dependent variable. However,

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3 See Cueto et al. (2009) for a description of the tests and analysis of the psychometric characteristics of the tests used by Young Lives in Round 2.

4 See Cueto and Leon (2012) for a detailed description of the Round 3 test and their psychometric properties.

as shown in Table 1, only a very small percentage of children are behind their normative age. The most likely reason for this is that in Peru there is automatic promotion for all first graders. In later grades, visual impairment could affect the probability of being overage for grade, if it has an effect on achievement that accumulates over time. We return to this in the final part of the paper.

3. Results

Table 1 shows the characteristics of the sample included in the analysis.

Table 1. *Sample characteristics (n=1724)*

Female (%)	49.19	
Age (years and SD)	7.46	(0.49)
Mother has incomplete secondary education or less (%)	63.57	
Wealth index (mean and SD)	0.54	(0.21)
Urban (%)	71.11	
Indigenous mother tongue (%)	13.23	
PPVT test (mean and SD)	59.17	(17.22)
Maths test (mean and SD)	14.26	(5.71)
EGRA test (mean and SD)	298.78	(14.33)
Overage (%)	5.10	
Log MAR better eye (mean and SD)	0.08	(0.15)
Log MAR worse eye (mean and SD)	0.14	(0.17)

Source: Young Lives database. All variables refer to Round 3 of the survey (2009).

In the sample, 63 children had eyeglasses; however, only 20 of these were measured both with and without them. Ideally, the results with and without eyeglasses should be compared. However, given the small number of children with both measures, we decided not to include children with glasses in this analysis. Thus, the results below refer only to children not using glasses.

Reviews such as those by Bourne et al. (2013) and Basch (2011) present results for visual acuity of the better eye. The correlation between the two eyes in our case was 0.85. Table 2 presents the descriptive results for the better and worse eye in each test, which show very similar tendencies. The results of the regressions also showed very similar results, therefore in this paper we only present the results for the better eye. With regards to the categories presented in Table 3, the literature usually only divides between mild and moderate vision impairment (and blindness or severe visual impairment, but there were no blind children in our sample). We further divided "good vision" into two categories to evaluate if this makes a difference. The initial results show a tendency for children with mild or moderate vision impairment to perform better in the tests. This is line with some of the studies mentioned above (e.g. Hannum and Zhang 2012).

Table 2. *Scores in Round 3, by vision (mean and standard deviation)*

Better eye	PPVT	Maths	EGRA
Good vision 1 (n=779)	55.20	13.44	296.36
	(17.89)	(5.89)	(14.25)
Good vision 2 (n=849)	62.11	14.85	300.63
	(16.16)	(5.44)	(14.26)
Mild vision impairment (n=86)	65.93	15.81	302.22
	(13.78)	(5.87)	(12.45)
Moderate vision impairment (n=10)	59.90	15.60	299.69
	(10.40)	(4.70)	(14.23)
Worse eye	**PPVT**	**Maths**	**EGRA**
Good vision 1 (n=530)	54.18	13.38	295.54
	(17.57)	(5.86)	(14.32)
Good vision 2 (n=1018)	60.88	14.51	300.01
	(16.86)	(5.57)	(14.15)
Mild vision impairment (n=153)	64.62	15.40	301.16
	(15.17)	(5.97)	(14.23)
Moderate vision impairment (n=23)	61.83	15.91	302.70
	(11.03)	(3.93)	(10.75)

Notes: Good vision 1 was defined as 20/20 or better; good vision 2 as 20/25 to 20/40; mild vision **impairment** as 20/50 to 20/63; and moderate vision **impairment** as 20/80 or worse.

Table 3 shows the correlation among visual acuity (better eye) as a continuous variable, and the dependent variables. The results show a similar pattern to that described above, with children with lower visual acuity scoring higher in all tests, although the correlations are weak.

Table 3. *Correlation between Log MAR score and dependent variables*

	PPVT	Maths	EGRA
Maths	0.6224		
EGRA	0.5644	0.6359	
Log MAR score	0.1876	0.1212	0.1265

Note: Higher scores in Log MAR indicate lower visual acuity.

The analysis above does not include any adjustment for covariates. Table 4 presents the results for the OLS regressions for visual acuity as a continuous variable for the better eye, controlling for covariates (included in the table).

Table 4. *OLS model standardised coefficients*

	Better eye		
	PPVT	Maths	EGRA
Log MAR score	-0.04 +	-0.06**	-0.03
	(-2.14)	(-0.84)	(-2.14)
Indigenous mother tongue	-0.08**	-0.12**	-0.09**
	(-1.56)	(-0.42)	(-1.26)
Boy	0.05*	0.06**	-0.04 +
	(-0.65)	(-0.23)	(-0.64)
Mother has complete secondary education or more	0.19**	0.18**	0.2**
	(-0.69)	(-0.28)	(-0.76)
Wealth index in Round 3	0.39**	0.3**	0.28**
	(-2.17)	(-0.79)	(-2.13)
Urban in Round 3	0.12**	0.08**	0.06*
	(-1.05)	(-0.36)	(-1)
Age in months	0.14**	0.22**	0.21**
	(-0.09)	(-0.03)	(-0.09)
Observations	1,600	1,724	1,593
R-squared	0.38	0.31	0.26
F-test	119.3	117.5	87.88

Notes: ** p<0.01, * p<0.05, + p<0.1. Only tests in Spanish are considered for PPVT and EGRA. Standardised coefficients and robust standard errors, in parenthesis, are shown.

The results show the opposite tendency to the correlation without controls, with children with higher scores (i.e. lower visual acuity) showing lower performance. The results are strongly significant for mathematics, marginally significant for vocabulary (PPVT), and not significant for reading, although in all cases the coefficient is negative. All control variables were significant. Overall, children from higher socio-economic status, urban areas, who are Spanish speakers, or who have more educated mothers show higher levels of performance and poorer visual acuity. Similar results have been identified in previous literature (Hannum and Zhang 2012).

The following tables explore the heterogeneity of the results. Specifically, for three dependent variables (PPVT, maths, EGRA) we estimated separate regressions by area of residence, mother tongue, maternal education and sex, controlling for the same covariates included above (not reported here, but available from authors). There is a loss in statistical power in these analyses, due to the reduction in the sample size, which should be considered in the interpretation of the results. Table 5 shows the results for the PPVT. There is a significant effect for rural children, but not for urban children. The results by sex show that there is a marginally significant effect on boys, but not on girls.

Table 5. *PPVT model – heterogeneities*

	Standardised coefficients	R-squared
Rural (n=377)	-0.09* (-6.42)	0.25
Urban (n=1223)	-0.02 (-2.21)	0.25
Non-indigenous (n=1483)	-0.03 (-2.15)	0.35
Indigenous (n=117)	-0.14 (-12.89)	0.17
Mother has not complete secondary education (n=972)	-0.04 (-2.91)	0.29
Mother has complete secondary education or more (n=628)	-0.04 (-3.09)	0.13
Female (n=780)	-0.02 (-2.94)	0.44
Male (n=820)	-0.06 + (-3.10)	0.32

Notes: ** p<0.01, * p<0.05, + p<0.1. Only tests in Spanish are considered. We controlled for area, sex, indigenous mother tongue, wealth index, mother's education, and on age at school. Standardised coefficients are shown. Robust standard errors are in parentheses.

Table 6 presents the same analysis for mathematics. There is a negative effect of visual acuity on the maths scores for rural children, for indigenous and non-indigenous children, for children of more educated mothers, and for boys.

Table 6. *Maths model – heterogeneities*

	Log Mar score (better eye)	R-squared
Rural (n=377)	-0.14** (1.92)	0.20
Urban (n=1223)	-0.03 (0.94)	0.21
Non-indigenous (n=1483)	-0.05* (0.88)	0.26
Indigenous (n=117)	-0.13* (2.88)	0.14
Mother has not complete secondary education (n=972)	-0.04 (1.11)	0.23
Mother has complete secondary education or more (n=628)	-0.09* (1.28)	0.15
Female (n=780)	-0.05 (1.21)	0.30
Male (n=820)	-0.07* (1.17)	0.32

Notes: ** p<0.01, * p<0.05, + p<0.1. We controlled for area, sex, indigenous mother tongue, wealth index, mother's education, and on age at school. Standardised coefficients are shown. Robust standard errors are in parentheses.

Table 7 presents the results for EGRA. There is a negative and significant effect on the EGRA scores for children with more educated mothers.

Table 7. *EGRA model – heterogeneities*

	Log Mar score (better eye)	R-squared
Rural (n=370)	-0.05 (5.83)	0.14
Urban (n=1223)	-0.03 (2.31)	0.20
Non-indigenous (n=1479)	-0.03 (2.22)	0.24
Indigenous (n=114)	-0.06 (8.18)	0.09
Mother has not complete secondary education (n=967)	0.01 (2.77)	0.16
Mothers has complete secondary education or more (n=626)	-0.09* (3.33)	0.14
Female (n=774)	-0.02 (3.00)	0.28
Male (n=819)	-0.04 (3.04)	0.24

Notes: ** p<0.01, * p<0.05, + p<0.1. Only tests in Spanish are considered. We controlled for area, sex, indigenous mother tongue, wealth index, mother's education, and on age at school. Standardised coefficients are shown. Robust standard errors are in parentheses.

Finally, we explored whether or not using a dummy variable as opposed to a continuous variable (Log MAR) would make a difference to the results. We combined the category 'mild vision impairment' with 'moderate vision impairment', as the number of children in the latter category was very small (see Table 2). Table 8 shows the results for the three dependent variables. There are no significant effects on the PPVT and EGRA tests. The results for mathematics are significant, with children with mild or moderate vision impairment scoring lower than those with good vision, but there was also a significant difference between children with good vision 2, compared with good vision 1.

Table 8. *Analysis with visual impairment categories*

	PPVT	Maths	EGRA
Mild or moderate vision impairment	-0.03 (1.16)	-0.06** (0.44)	-0.02 (1.23)
Good vision 2	-0.01 (0.82)	-0.07** (0.27)	0.02 (0.79)
Observations	1,600	1,724	1,593
R-squared	0.37	0.31	0.26
F-test	103.9	105.1	77.13

Notes: ** p<0.01, * p<0.05, + p<0.1. Reference group: Good vision 1 (20/20 or better). We controlled for area, sex, indigenous mother tongue, wealth index, mother's education, and on age at school. Standardised coefficients are shown. Robust standard errors are in parentheses.

4. Discussion

This working paper aimed to estimate the relationship between visual acuity and performance in standardised tests for primary school children in Peru. Previous studies on the relationship between visual acuity and educational performance have shown mixed results. In this paper, while our unadjusted results showed a tendency for those with lower visual acuity to perform better, the adjusted results showed the reverse: that children with poorer vision also show poorer performance. Some previous studies also found that children with poor visual acuity perform worse (e.g. Gomez-Neto et al. 1997; Bruce et al. 2016). Other studies found no association (e.g. Dirani et al. 2010,) or even a negative association (e.g. Mutti et al. 2002; Hannum and Zhang 2012). However, a rigorous experimental study in China found a positive impact of providing glasses to children with poor visual acuity (Glewwe et al. 2016), in keeping with our results. Our results from the regressions were somewhat mixed, with stronger results for mathematics, followed by vocabulary and reading. In the reading test, the tendency was the same as in the other tests, but with statistically non-significant results.

What explains the differences in results is an interesting topic for further research. Other studies of educational performance in Peru have also found significant results for mathematics, and not for reading. For example, Cueto, Leon and Miranda (2016) found an association between classroom composition and achievement in mathematics, but not with reading. The reason suggested by these authors is that while reading and general verbal skills may be learned in different environments, including at home, mathematics is more likely to be learned only at school. Along these lines, another possible explanation is that while many reading activities can be followed in notebooks and textbooks, which children can hold close to their faces, mathematics is often explained by teachers using a blackboard, which may be difficult for students to see from their desks. Cueto, Leon and Miranda (2016) also provide evidence that nationally, performance in reading is well above performance in mathematics, so it may be that variables such as visual acuity matter more at lower levels of achievement for the whole population. These hypotheses would need to be studied empirically.

In regards to heterogeneity of results, again, the mathematics model was significant for most of the regressions. When we compared different groups, the ones particularly likely to be significant were rural children, children of more educated mothers, and boys. However, all coefficients were negative, as expected, suggesting that visual acuity should be checked for the whole population (it is likely that with a larger sample, all results would have been statistically significant). For the analysis by categories, we found a significant difference in favour of the group we called 'good vision 1' (20/20 vision or better). The significance of this result is that glasses or other treatments are often only recommended for children with mild, moderate or severe visual impairment. Our results suggest that even children close to but not reaching the 20/20 mark, those with marginal reduction of visual acuity, could benefit from wearing glasses. This would need to be tested in a field trial.

Visual impairment is an issue of international relevance. WHO and the International Agency for the Prevention of Blindness (IAPB) launched 'Vision 2020: the Right to Sight' in 1999.[5] They recommend that all schoolchildren are screened for visual acuity, and glasses are provided to those who show refractive error (Gilbert and Foster 2001). This is not common practice in developing countries, and does not regularly or usually occur in Peru´s public schools. However, there have been some trials to test children at school and provide them with eyeglasses. Latorre-Arteaga et al. (2014) successfully trained 26 teachers in rural communities in the highlands of Peru to screen preschool and primary school children for visual acuity, using the Snellen Chart. In a follow-up study, Latorre-Arteaga et al. (2016) improved the materials and expanded training to 355 teachers and school directors to test their children for visual acuity. In both cases, students were referred to health centres to confirm the results, which were largely validated. These studies did not test for impact of treatment on school performance, only for the validity of training school personnel to test for visual acuity. However, the results suggest that training teachers could be an efficient way to get a first diagnosis of students, who would then need to be examined by professionals to diagnose specific treatment.

In terms of this study's limitations, the most important is that the design does not allow full control of potential covariates and is restricted to those that were included in the analyses, so the results should not be considered a strict estimation of the impact of poor visual acuity on vocabulary, reading and mathematics. The ways in which visual acuity may affect educational performance can be diverse, as suggested in the first section of this paper. Poor visual acuity could also have a cumulative effect, as children with low performance may eventually repeat a grade or even drop out of school. This is something that would need to be tested with older students as they progress, especially to secondary school. We believe, however, that given these results and those of other studies reviewed above, there is sufficient evidence to recommend screening children for visual acuity, especially in public and rural schools, as children in these schools often do not attend medical check-ups regularly, while children of in urban, private schools do.

For future studies, a trial could be established along the lines of the study by Glewwe, Park and Zhao (2016) in China, but collecting information not only on the impact of the intervention on achievement, but also on how the provision of glasses changes the ways in which students learn. There could be several changes, including those mentioned by Basch (2011: 601) at the beginning of this article. In particular, we suggest that future studies explore how the provision of glasses affects learning in reading and mathematics differently, something that has been reported in this study as well as others. In addition, the provision of glasses could have an effect on achievement through the reduction of grade repetition. Therefore, a study that looked at different grade levels and followed children for at least two years, to test for repetition, would be ideal.

[5] Descriptions of the programme, goals and references are available at https://www.iapb.org/vision-2020.

References

Angle, J. and D. Wissmann (1980) 'The Epidemiology of Myopia', *American Journal of Epidemiology* 111.2: 220-228.

Basch, C. (2011) 'Vision and the Achievement Gap Among Urban Minority Youth', *Journal of School Health* 81.10: 599-605.

Bourne, R., G. Stevens, R. White, J. Smith, S. Flaxman, H. Price, J. Jonas, J. Keeffe, J. Leasher, K. Naidoo, K. Pesudovs, S. Resnikoff, and H. Taylor (2013) 'Causes of Vision Loss Worldwide 1990–2010: a Systematic Analysis', *Lancet Global Health* 1: e339-e349.

Bruce, A., L. Fairley, B. Chambers, J. Wright, and T. Sheldon (2016) 'Impact of visual acuity on developing literacy at age 4– 5 years: a cohort nested cross-sectional study', *BMJ Open* 6: e010434.

Cueto, S., J. Escobal, M. Penny, and P. Ames (2011) *Tracking Disparities: Who Gets Left behind? Initial Findings from Peru. Round 3 Survey Report,* Oxford: Young Lives.

Cueto, S. and J. Leon (2012) *Psychometric Characteristics of Cognitive Development and Achievement Instruments in Round 3 of Young Lives*, Young Lives Technical Note 25, Oxford: Young Lives.

Cueto, S., J. Leon, G. Guerrero, and I. Munoz (2009) *Psychometric Characteristics of Cognitive Development and Achievement Instruments in Round 2 of Young Lives*, Young Lives Technical Note 15, Oxford: Young Lives.

Cueto, S., J. Leon, and A. Miranda (2016) 'Classroom composition and its association with students´ achievement and socioemotional characteristics in Peru', *Assessment in Education: Principles, Policy and Practice* 23.1: 126-148.

Cueto, S., A. Miranda, and M.C. Vásquez (2016) 'Inequidades en educación', in *Investigación para el desarrollo en el Perú: once Balances*, GRADE, 55-108. Lima: GRADE.

Defensoría del Pueblo (2001) 'Situación de la educación especial en el Perú: Hacia una educación de calidad'. www.defensoria.gob.pe/modules/Downloads/informes/defensoriales/informe_63.pdf (accessed 1 March 2017).

Defensoría del Pueblo (2007) 'Educación inclusiva: Educación para todos. Supervisión de la política educativa para niños y niñas con discapacidad en escuelas regulares'. http://repositoriocdpd.net:8080/bitstream/handle/123456789/289/Inf_EducacionInclusivaSupervision_2007.pdf?sequence=1 (accessed 1 March 2017).

Defensoría del Pueblo (2011) 'Los niños y niñas con discapacidad: Alcances y limitaciones en la implementación de la política de educación inclusiva en instituciones educativas del nivel primaria'. www.defensoria.gob.pe/modules/Downloads/informes/defensoriales/informe-155.pdf (accessed 1 March 2017).

Escobal, J. and E. Flores (2008) *An Assessment of the Young Lives Sampling Approach in Peru*, Young Lives Technical Note 3, Oxford: Young Lives.

Dirani, M., X. Zhang, L. Goh, T. Young, P. Lee, and S. Mei Saw (2010) 'The Role of Vision in Academic School Performance', *Ophthalmic Epidemiol* 17.1: 18-24.

Dunn, L., E. Padilla, D. Lugo and L. Dunn (1986) 'Manual del Examinador para el Test de Vocabulario en Imágenes Peabody: Adaptación Hispanoamericana (Peabody Picture Vocabulary Test: Hispanic-American Adaptation)', Minnesota: AGS.

Gilbert, C. and A. Foster (2001) 'Childhood blindness in the context of VISION 2020 – The Right to Sight', *Bulletin of the World Health Organization* 79.3: 227-232.

Glewwe, P., A. Park, and M. Zhao (2016) 'A Better Vision for Development: Eyeglasses and Academic Performance in Rural Primary Schools in China', *Journal of Development Economics* 122: 170-182.

Goldstand, S., K. Koslowe, and S. Parush (2005) 'Vision, visual-information processing, and academic performance among seventh-grade schoolchildren: A more significant relationship than we thought?', *American Journal of Occupational Therapy* 59: 377-389.

Gomez-Neto, J., E. Hanushek, R. Hélio, and R. Frota-Bezzera (1997) 'Health and Schooling: Evidence and Policy implications for Developing Countries', *Economics of Education Review* 16.3: 271-282.

Greene, W. (2003) *Econometric Analysis* (5th edition), New York: MacMillan.

Hannum, E., and Y. Zhang (2012) 'Poverty and Proximate Barriers to Learning: Vision Deficiencies, Vision Correction and Educational Outcomes in Rural Northwest China', *World Development* 40.9: 1921-1931.

Instituto Nacional de Estadística e Informática (2014) 'Primera Encuesta Nacional Especializada sobre Discapacidad 2012'. www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1171/ENEDIS%202012%20-%20COMPLETO.pdf (accessed 2 February 2017).

Latorre-Arteaga, S., D. Gil-González, C. Bascarán, R. Hurtado, M. Peral, and G. Carrillo (2016) 'Visual health screening by scholteachers in remote communities of Peru: implementation research', *Bulletin of the World Health Organization* 94: 652-659.

Latorre-Arteaga, S., D. Gil-González, O. Enciso, A. Phelan, A. García-Muñoz, and J. Kohler (2014) 'Reducing visual deficits caused by refractive errors in school and preschool children: results of a pilot school program in the Andean region of Apurimac, Peru', *Global Health Action* 7: 22656.

Leasher, J., V. Lansingh, S. Flaxman, J. Jonas, J. Keeffe, K. Naidoo, K. Pesudovs, H. Price, J. Silva, R. White, T. Wong, S. Reshikoff, H. Taylor, and R. Bourne (2014) 'Prevalence and causes of vision loss in Latin America and the Caribbean: 1990–2010', *British Journal of Ophthalmology* 98.5: 619-28.

Lu, B., N. Congdon, X. Liu, K. Choi, D. Lam, M. Zhang, M. Zheng, Z. Zhou, L. Li, X. Liu, A. Sharma, and Y. Song (2009) 'Associations Between Near Work, Outdoor Activity, and Myopia Among Adolescent Students in Rural China', The Xichang Pediatric Refractive Error Study Report No. 2. *Arch. Ophthalmol* 127.6:. 769-775.

Mutti, D., L. Mitchell, M. Moeschberger, L. Jones, and K. Zadnik (2002) 'Parental Myopia, Near Work, School Achievement, and Children's Refractive Error', *Investigative Ophthalmology and Visual Science* 43.12: 3633-3640.

Poppe, R. (2014) 'Poor Eyesight and Educational Outcomes in Ethiopia', *The Review of Black Political Economy* 41: 205-223.

RTI International (2009) *'Early Grade Reading Assessment Toolkit'.* http://s3.amazonaws.com/inee-assets/resources/EGRA_Toolkit_Mar09.pdf (accessed 13 April 2017).

SPIE (2017) 'Visual Acuity'. https://spie.org/publications/fg04_p19-20_visual_acuity (accessed 5 April 2017).

Stevens, G., R. White, S. Flaxman, H. Price, J. Jonás, J. Keeffe, J. Leasher, K. Naidoo, K. Pesudovs, S. Resnikoff, H. Taylor, and R. Bourne (2013) 'Global Prevalence of Vision Impairment and Blindness: Magnitude and Temporal Trends, 1990–2010', *American Academy Ophthalmology* 120.12: 2377-2384.

Thurston, A. (2014) 'The Potential Impact of Undiagnosed Vision Impairment on Reading Development in the Early Years of School', *International Journal of Disability, Development and Education* 61.2: 152-154.

UNESCO (2016) 'Education for people and planet: Creating sustainable futures for all. Global Education Monitoring Report 2016', Paris: UNESCO. http://unesdoc.unesco.org/images/0023/002322/232205e.pdf (accessed 1 April 2017).

United Nations (1949) 'United Nations Universal Declaration of Human Rights 1948'. www.un.org/en/universal-declaration-human-rights (accessed 20 April 2017).

United Nations (2017) 'Goal 4: Ensure inclusive and quality education for all and promote lifelong learning'. www.un.org/sustainabledevelopment/education (accessed 5 April 2017).

World Health Organization (WHO) (2017) 'Heath Topics – Disabilities'. www.who.int/topics/disabilities/en (accessed 5 April 2017).

World Health Organization and World Bank (2011) *World Report on Disability*. Geneva: WHO.

Appendix 1

Comparison of children included and not included in the analytical sample (student's t-test).

Variable	Obs	Difference in means	Standard error
Wealth index	1935	-0.020	0.016
Sex	1943	0.033	0.036
Age	1942	-0.037	0.036
Mother's education	1906	-0.064 +	0.039
Indigenous mother tongue	1915	-0.04	0.029
Area (urban-rural)	1943	-0.037	0.031
On age at school	1917	0.05*	0.023
PPVT	1842	3.75 +	2.138
Maths	1884	0.702	0.555
EGRA	1913	-2.478*	1.017

Notes: Analytic sample: 1724 observations. ** $p<0.01$, * $p<0.05$, + $p<0.1$. Formula used: Mean of sample included in the analysis – mean of sample not included in the analysis due to missing data.

Does Visual Acuity Have an Effect on Children's Educational Achievement? Evidence from Peru

Inequity is an important issue for many international initiatives, including the current Sustainable Development Goals (SDGs). One aspect of inequity that has received little attention is the impact of disability on education. This working paper explores whether mild or moderate levels of visual impairment are associated with educational performance for 7 and 8-year-old children in Peru. Descriptive statistics from the Young Lives sample suggested that children with poorer visual acuity have better performance in mathematics, reading and vocabulary tests. However, when several characteristics of the children and their families are included as controls, the results reverse, and we found a significant negative effect of poor visual acuity on mathematics tests, marginally significant for vocabulary, and not significant for reading.

We also explored the impact for different groups of children and whether the results changed if we used categories of mild and moderate visual impairment instead of a continuous variable. We found that even marginally reduced visual acuity, just below 20/20, is associated with a lower performance in mathematics. The results outlined in this paper, along with other research in the field, support the visual screening of all schoolchildren. The final section of the paper discusses the results and policy options, including the participation of teachers in screening children for visual impairment.

Young Lives

An International Study of Childhood Poverty

About Young Lives

Young Lives is an international study of childhood poverty, involving 12,000 children in 4 countries over 15 years. It is led by a team in the Department of International Development at the University of Oxford in association with research and policy partners in the 4 study countries: Ethiopia, India, Peru and Vietnam.

Through researching different aspects of children's lives, we seek to improve policies and programmes for children.

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Young Lives is coordinated by a small team based at the University of Oxford, led by Professor Jo Boyden.

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- *Centre for Analysis and Forecasting, Vietnamese Academy of Social Sciences, Vietnam*
- *General Statistics Office, Vietnam*
- *Oxford Department of International Development, University of Oxford, UK*

Contact:
Young Lives
Oxford Department of International Development,
University of Oxford,
3 Mansfield Road,
Oxford OX1 3TB, UK
Tel: +44 (0)1865 281751
Email: younglives@younglives.org.uk
Website: www.younglives.org.uk

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