The Impact of Eyeglasses on the Academic Performance of Primary School Students: Evidence from a Randomized Trial in Rural China

Paul Glewwe
University of Minnesota

Albert Park
Hong Kong University of Science & Technology

Meng Zhao
Waseda University

Presentation for 9th Itaú Internationnal Seminar on Economic Evaluation of Social Projects

October 22, 2012

I. Background

China has achieved nearly universal primary school enrollment.

However, in rural areas, especially in poorer provinces, many children do not meet the learning goals set out in the curriculum.

About 10% of school-age (age 5-15) children have refraction errors (myopia, hypermetropia. strabismus, amblyopia, and astigmatism), which account for about 97% of the vision problems among those children.

Almost all refraction errors can be corrected with properly fitted eyeglasses, but most children with refraction problems in low income countries do not have glasses.

In China, a study by Zhao et al. (2000) in one district in Beijing found that 12.8% of children age 5-15 years had vision problems, of which 90% were due to refraction errors. Only 21% of the children with vision problems had glasses.

In rural areas, children with vision problems are even less likely to wear glasses, as will be seen below.

There are very little data on vision problems among school-age children in developing countries, so there is very little research on the impact of poor vision on students' academic performance.

One published study; Gomes-Neto et al. (1997) found that primary school children with poor vision:

- had a 10% higher probability of dropping out
- had an 18% higher probability of repeating a grade
- scored 0.2 to 0.3 standard deviations lower on achievement tests

Yet these estimates could be biased:

1. To the extent that some of these children wore glasses their vision could be correlated with unobserved factors that determine school performance, such as parental preferences for educated children.

2. Even if none of these children wore glasses, students' vision can be affected by their home environment and by their daily activities, thus their vision could be correlated with other unobserved factors (e.g. studying), leading to biased estimation results.

II. Project Description and Data Available

A. The Gansu Vision Intervention Project.

In 2004, a team of Chinese and international researchers, implemented a randomized trial to examine the impact of providing eyeglasses to primary school students with poor vision in two counties, Yongdeng and Tianzhu, of Gansu province.

The project covered almost all students in grades 4-6 in all primary schools from each of these two counties.

Gansu province is very poor. It's low per capita disposable income places Gansu at a rank of 30 out of 31 provinces; only Tibet is poorer.

Yongdeng county…

…has 23 townships;18 participated in the program
(5 townships were dropped, 1 county seat + 4 remote).

These 18 townships have 155 primary schools.

Of the 18 townships in Yongdeng, 9 were randomly chosen to receive eyeglasses in 2004; the other 9 were the control group.

Tianzhu county…

…has 22 townships, of which 19 participated (dropped 3).

These 19 townships have 101 primary schools.

10 of Tianzhu's 19 townships were randomly chosen to participate in the program; the other 9 were the control group.

Assignment to Treatment and Control groups

In each county, all townships were ranked by rural income per capita in 2003. Starting with the first 2 (2 richest) townships, one was randomly assigned to treatment group, the other to the control group.

In Tianzhu, the 19th township, the poorest, was not paired with another other township; a random draw assigned it to the group that received eyeglasses.

The primary schools within each township were either all assigned to the treatment group or all assigned to the control group.

Some details (problems)

Unfortunately, 5 control townships (2 in Yongdeng and 3 in Tianzhu) were provided with eyeglasses because, after providing the eyeglasses to treatment townships they had money for more glasses.

Another control township in Yongdeng was incorporated into a township that received eyeglasses, so that control was compromised.

In all 6 cases, both the control township and the treatment township with which it was paired were dropped from the analysis.

Thus there were 6 pairs of townships in Yongdeng and 6 pairs (plus the poorest township, which was randomly assigned to the treatment group) in Tianzhu for which the randomization was carried out according to the plan. All of the regression analysis below (expect for one robustness check) is limited to these 25 townships.

B. Data Used in the Analysis (Gansu Vision Intervention Project)

The basic information come from school records: grade in 2004-05 school year, sex, ethnicity, date of birth, and the occupation and education of the head of household (usually the father).

Scores on exams given at the end of each semester in each grade since the student enrolled at that school (usually grade 1). Separate scores for three subjects: Chinese, mathematics and science.

School health data: whether student wears glasses (and if so, the grade the student was in when he/she started to wear glasses), height, weight, hemoglobin count, vision measurement for each eye.

The 25 townships contain about 19,000 students in grades 3-5 spread across 165 schools (103 treatments and 62 controls).

B. Data Used in the Analysis (Gansu Survey of Children & Families)

Panel data on 2000 children in rural areas of Gansu province.

First interviewed in 2000, when they were 9-12 years old.

Round 2 in 2004 (13-16 years old) and Round 3 in 2007-09.

In Round 2, about 800 younger siblings of school age were also interviewed. Vision tests were given, as well as questions regarding wearing eyeglasses and vision problems. This will be used to investigate why many children who need eyeglasses do not have them.

Table 1: Descriptive Statistics from Tianzhu and Yongdeng Counties (Compliant Townships only)

		Tianzhu	Yongdeng	Both Counties
Number of children in grades 4-6 in 2004-05		12,772	6,130	18,902
Children with vision problems		1,742 (13.6%)	787 (12.8%)	2,529 (13.4%)
Of which:				
Had glasses already		36 (2.1%)	22 (2.8%)	58 (2.3%)
Did not have glasses		1,706 (97.9%)	765 (97.2%)	2,471 (97.7%)

		Tianzhu	Yongdeng	Both Counties
Spring 2004 test scores (before intervention):				
Students without vision problems				
Chinese		79.0	78.6	78.9
Mathematics		79.2	79.0	79.1
Science		80.8	80.6	80.7
Students with vision problems				
Chinese		78.7	77.1	78.2
Mathematics		79.2	76.8	78.5
Science		80.8	80.2	80.6

These data exclude pairs of townships where the randomization plan was not correctly implemented.

Vision problem is defined as a visual acuity score < 4.9 in one or both eyes. Although the 249 children for whom one or both eyes had a score of 4.9 were offered glasses, only 17 (6.8%) accepted the glasses, so the analysis focuses on children for whom one or both eyes had a score less than 4.9.

The test score data in Table 1 suggest that vision problems have little effect on students' academic performance.

But…

…this conclusion may be misleading because school performance can affect eyesight. Medical studies have shown that doing "near-work" (spending lots of time doing activities with the eyes focused on objects about 1 meter from one's eyes) can cause myopia.

This implies that students who spend more time studying are more likely to develop myopia, the most common refractive eye problem.

OLS regressions of mean (over both eyes) visual acuity on test scores in Chinese in grade 1, controlling for school fixed effects, grade, parents' education & occupation (on the sample children in grades 4-6) show a ***negative*** impact, statistically significant at 1% level).

Table 2: Implementation of Gansu Vision Intervention Project

		Tianzhu	Yongdeng	Both Counties
Students in grades 4-6 in 2004-05 with vision problems		1,742	787	2,529
Of which:				
In control schools		889	112	1,001
In program schools		853	675	1,528
Students in program schools who:				
Accepted the offer to receive glasses		649	417	1,066
Did not accept the offer to receive glasses:		204 (23.9%)	258 (38.2%)	462 (31.5%)

These figures are for townships where randomization was correctly implemented.

III. Methodology

For ease of interpretation, all estimates use a standardized test scores as the dependent variable; test scores are standardized (for each subject and grade) by subtracting the mean and then dividing by the standard deviation (mean and standard deviation of the control group schools).

A. Estimation of the Impact of the Offer of Eyeglasses (ITT Effect).

The simplest estimate of the impact of the program on children ***with poor vision*** is to compare the mean test scores of such children in the program schools with the mean test scores of such children in the control schools.

This estimates the impact of the ***offer*** to receive eyeglasses, not the impact of the eyeglasses themselves, since about a third of the children who were offered eyeglasses did not take them for various reasons.

This t-test can be calculated by regressing the (standardized) test score variable (T) on a constant term and a dummy variable that indicates enrollment in a program (treatment) school (P):

$$T = \alpha + \beta P + u \qquad (1)$$

The residual term u is uncorrelated with P due to the randomized design.

To obtain account for correlation of u for students in the same school or same township, school random effects are added. ***In addition,*** hetero-scedasticity of unknown form is allowed for at the township level. This is both very robust and uses information of whether 2 students in the same township are in the same school or in two different schools.

Also, since the number of townships is small (25), wild bootstrap p-values are calculated, as recommended by Cameron, Gelbach & Miller (2008).

To increase precision, we condition on initial test scores in all regressions.

More precise estimates of the program effect (β) can be obtained by estimating a model that includes not only students with poor eyesight but also students with good eyesight:

$$T = \alpha + \pi PV + \tau P + \beta PV*P + u \qquad (2)$$

where PV is a dummy variable indicating poor vision.

This specification also has the advantage that it allows for school fixed effects, which could yield more precise estimates of β. (In fact, the results are very similar to random effects estimates).

B. IV Estimates of the Impact of Providing Eyeglasses.

The methods presented so far estimate the impact of being offered the eyeglasses, not the impact of receiving eyeglasses.

In general, the impact of being offered eyeglasses will be less than the impact of receiving them because those students who are offered but do not receive glasses do not benefit from the offer.

OLS estimation of the benefit of receiving eyeglasses may yield biased estimates because parents and/or students who take up the offer of eyeglasses may differ in unobserved ways from students for whom the offer is turned down. For example, the parents of students who take up the offer may have more favorable attitudes toward education and so may do other things that raise the test scores of their children.

One can use instrumental variable (IV) estimation to obtain consistent estimates of the impact of actually receiving eyeglasses using the same equations presented above, replacing P (the offer to receive eyeglasses) with "G", actually receiving the eyeglasses.

While G is likely to be correlated with the residual term, P can be used as an instrument for G; P is, by definition, uncorrelated with u, and it has strong explanatory power for G.

Note that G = 1 not just for students who agreed to accept glasses in the program schools but also for students who wear their own glasses, either in the program schools or in the control schools.

IV estimates for equation (1) are straightforward; one need only replace P with G and use P as an instrument for G.

But there is one complication with IV estimates of equation (2) …

…To see the problem, note that automatically replacing P with G in that equation yields $T = \alpha + \pi PV + \tau G + \beta PV*G + u$.

Although it is possible to be in a program school if one does not have poor vision, it does not make sense to wear glasses if one does not have poor vision, which implies that G = 0 whenever PV = 0, and thus G and PV*G are perfectly correlated.

While this correlation is not exactly 1 in the data (it is 0.86), this is only due to the fact that there are a very small percentage of students who report wearing classes even though they have good vision. Thus IV estimates of (2) drop the term τG.

Table 4: Pre-Program Differences between Compliant and Non-Compliant Townships

Variable	*Compliant Mean*	*Non-Compliant Mean*	*Difference*	*Random Effects Difference*	*Random Effects p-values based on Wild Bootstrap*
		All Children			
Chinese	-0.121	-0.117	-0.004	-0.152	0.276
Math	-0.100	-0.069	-0.031	-0.155	0.190
Science	-0.058	-0.099	0.041	-0.068	0.570
Average	-0.113	-0.115	0.002	-0.153	0.268
Ethnic minority	0.136	0.236	-0.100	-0.109	0.294
Poor vision	0.134	0.167	-0.033	-0.027	0.408
Visual acuity	5.03	5.03	0.00	0.00	0.992
Male	0.535	0.531	0.004	0.003	0.686
Head years educ.	8.82	8.05	0.78	0.47	0.118
Age	10.68	10.81	0.13	-0.02	0.864

Children with Poor Vision Only

Variable	*Compliant Mean*	*Non-Compliant Mean*	*Difference*	*Random Effects Difference*	*Random Effects p-values based on Wild Bootstrap*
Chinese	-0.192	-0.067	-0.125	-0.107	0.496
Math	-0.126	-0.018	-0.107	-0.121	0.454
Science	-0.084	-0.034	-0.050	-0.076	0.616
Average	-0.163	-0.048	-0.114	-0.122	0.528
Ethnic minority	0.114	0.229	-0.114	-0.109	0.292
Visual acuity	4.59	4.57	0.02	0.03	0.490
Male	0.485	0.479	0.007	0.013	0.548
Head yrs educ	8.60	7.94	0.66	0.50	0.188
Age	10.93	10.88	0.05	0.02	0.962

Table 5: Pre-Program Differences between Treatment and Control Groups (25 townships where randomization was correctly implemented)

Variable	*Treatment Mean*	*Control Mean*	*Difference*	*Random Effects Difference*	*Random Effects p-values based on Wild Bootstrap*
			All Children		
Chinese test	-0.089	-0.180	0.091	0.030	0.780
Math test	-0.093	-0.112	0.020	-0.004	0.990
Science test	-0.013	-0.142	0.129	0.073	0.360
Average test	-0.079	-0.176	0.097	0.040	0.656
Ethnic minority	0.167	0.077	0.090	-0.073	0.022
Visual acuity	5.02	5.05	-0.02	-0.039	0.134
Poor vision	0.125	0.151	-0.026	0.002	0.888
Male	0.535	0.535	0.000	-0.002	0.906
Head yrs educ	8.97	8.55	0.42	0.38	0.140
Age	10.47	11.07	-0.60	-0.22	0.134

Children with Poor Vision

Variable	*Treatment Mean*	*Control Mean*	*Difference*	*Random Effects Difference*	*Random Effects p-values based on Wild Bootstrap*
Chinese test	-0.195	-0.188	-0.008	0.045	0.712
Math test	-0.185	-0.036	-0.149	-0.042	0.726
Science test	-0.094	-0.068	-0.026	0.001	0.982
Average test	-0.192	-0.118	-0.074	0.003	0.952
Ethnic minority	0.159	0.046	0.113	-0.059	0.016
Visual acuity	4.55	4.66	-0.11	-0.13	0.002
Male	0.500	0.463	0.037	0.02	0.670
Head yrs educ	8.58	8.63	-0.05	0.50	0.194
Age	10.77	11.19	-0.42	-0.32	0.042

Statistical significance of mean differences is based on regressions that account for clustering at the township level.

Table 8: Estimated Program Effect After One Year (Compliant Sample) (conditioning on 2004 test scores)

	Chinese	Math	Science	Average
Explanatory Variables				
Equation (1): School Random Effects, only Pupils w/ Bad Vision *N*=2,474				
Treatment Township (β)	0.091 (0.078) [0.374]	0.097 (0.084) [0.454]	0.186*** (0.055) [0.016]	0.158** (0.077) [0.214]
Equation (2): School Random Effects, All Students *N* = 18,504				
Poor Vision×Treatment Township (β)	0.117** (0.051) [0.020]	0.072 (0.055) [0.230]	0.071 (0.044) [0.156]	0.109** (0.049) [0.048]

Table 8: Effect of Eyeglasses after One Year (Compliant Sample) (conditioning on 2004 test scores)

	Chinese	Math	Science	Average
Explanatory Variables				
Equation (1): School Random Effects, only Pupils w/ Bad Vision *N*=2,474				
Treatment Township (β)	0.130 (0.109)	0.137 (0.120)	0.261*** (0.073)	0.224** (0.110)
Equation (2): School Random Effects, All Students *N* = 18,503				
Poor Vision×Treatment Township (β)	0.162** (0.074)	0.103 (0.080)	0.107* (0.060)	0.156** (0.071)

Note: The wild bootstrap has not been developed for IV estimation.

Tables 9 and 11: Spillovers and Robustness Checks (IV w/ Full Sample) (conditional on 2004 test scores)

	Chinese	Math	Science	Average
Explanatory Variables				
Equation (1): School Random Effects, Pupils w/ Good Vision *N* = 16,030				
Treatment Township (β)	-0.065 (0.060) [0.480]	-0.015 (0.050) [0.808]	0.029 (0.063) [0.776]	-0.022 (0.064) [0.856]
Equation (1): School RE, Pupils w/ Bad Vision, Full Sample (IV) *N*=4,093				
Treatment Township (β)	-0.084 (0.125)	-0.100 (0.154)	-0.048 (0.140)	-0.099 (0.161)
Equation (2) School RE, All Pupils, Full Sample (IV) *N* = 28,270				
Poor Vision×Treatment Township (β)	0.093 (0.090)	0.090 (0.102)	0.002 (0.088)	0.082 (0.096)

Table 13: Interaction Effects Between Program, Vision & 2004 Test Scores

Explanatory Variables	*Dep. Var. Avg. Test Score*	
Equation (1): School Random Effects, Only Pupils w/ Bad Vision *N* = 2,474		
Treatment Township (β)	0.171**	0.136*
	(0.077)	(0.079)
	[0.130]	[0.236]
Very Poor Vision × Treatment Township	0.052	--
	(0.040)	
Avg. Test Score 2004 × Treatment Township	--	-0.106
		(0.092)
		[0.284]
Equation (2): School Random Effects, All Students *N* = 18,478		
Poor Vision × Treatment Township (β)	0.119**	0.081*
	(0.051)	(0.043)
	[0.054]	[0.092]
Very Poor Vision × Treatment Township	-0.064	
	(0.077)	
	[0.410]	
2004 Avg. Test Score × Very Poor Vision		-0.166***
× Treatment Township		(0.055)
		[0.014]

Table 14: Probit Estimates of Factors Associated with Accepting Eyeglasses

Variable	Mean	Coefficient	Marginal Effects
Average visual acuity	4.551	-1.467*** (0.546)	-0.494*** (0.197)
Female	0.500	-0.242*** (0.059)	-0.082*** (0.019)
Had glasses before program began	0.032	0.662* (0.379)	0.177* (0.077)
Household head is a teacher	0.016	-0.594*** (0.232)	-0.224*** (0.094)
Household head is village leader (cadre)	0.016	-0.923* (0.484)	-0.352* (0.182)
Township per cap. income, 2003 (yuan/yr)	1511.5	0.00045** (0.00019)	0.00015** (0.00006)
Head years of schooling	8.58	-0.012 (0.024)	-0.004 (0.008)
Test score, spring 2004 (avg. for 3 subjects)	-0.187	-0.012 (0.074)	-0.004 (0.025)
Tibetan	0.145	-0.038 (0.140)	-0.013 (0.048)
Grade in 2003-2004 (3, 4 or 5)	4.27	-0.078 (0.127)	-0.026 (0.043)
Observations		1497	

Table 15: Mother's Assessment of Vision and Actual Visual Acuity (children age 8-15 who were enrolled in primary school in 2004)

Measured Acuity	*Mother's Assessment*					
	Very bad	Bad	Fair	Good	Very good	Don't know
Good (≥ 5.0)	1	4	92	251	367	4
Fair (4.8-5.0)	0	0	18	29	52	0
Poor (< 4.8)	1	7	17	14	29	1

Table 16: Children's Reports of Vision Problems, by Actual Visual Acuity (children age 8-15 who were enrolled in primary school in 2004)

Measured Visual Acuity	*Child Reports of Vision Problems*		
	Difficulty seeing blackboard (%)	Trouble doing homework due to poor vision (%)	Felt pain in eyes when studying at home in dim light (%)
Good (≥ 5.0)	8.5	6.7	19.1
Fair (4.8-5.0)	7.1	7.1	21.2
Poor (< 4.8)	30.4	26.1	29.0

Source: Gansu Survey of Children and Families.

Table 17: Determinants of Student Wearing of Eyeglasses (from 2004 GSCF) N = 921

VARIABLES	*Coefficient Estimates from Probit Specification*					*Marginal Effects*
eyesightmax	-1.329***	-0.858**	-0.852**	-0.670	-0.783*	-0.0196
	(0.374)	(0.412)	(0.420)	(0.423)	(0.417)	(0.0120)
Sex	-0.228	-0.210	-0.228	-0.145	-0.155	-0.00396
	(0.169)	(0.177)	(0.173)	(0.173)	(0.173)	(0.00417)
Age	0.0849**	0.0902***	0.0861**	0.101***	0.101***	0.00253**
	(0.0339)	(0.0341)	(0.0346)	(0.0375)	(0.0386)	(0.00106)
Faedu	-0.0210	-0.0114	-0.0104	-0.000136	0.00228	5.69e-05
	(0.0325)	(0.0341)	(0.0334)	(0.0365)	(0.0375)	(0.000930)
Moedu	0.0919***	0.0895***	0.0936***	0.0851**	0.0722*	0.00180*
	(0.0316)	(0.0326)	(0.0331)	(0.0364)	(0.0372)	(0.00105)
logexppc00	0.553***	0.515***	0.530***	0.497**	0.463**	0.0116**
	(0.184)	(0.190)	(0.189)	(0.204)	(0.201)	(0.00562)
morep_visbad		0.898***	0.887***	0.858***	0.809***	0.0508
		(0.326)	(0.329)	(0.307)	(0.298)	(0.0364)
parep_visbad		0.603	0.605	0.558	0.542	0.0247
		(0.380)	(0.385)	(0.357)	(0.364)	(0.0251)
glasscostmed			-0.00366*	-0.00375*	-0.00451**	-0.000113
			(0.00215)	(0.00218)	(0.00225)	(7.37e-05)
glassdistmed			0.00164	0.000704	0.000869	2.17e-05
			(0.00422)	(0.00392)	(0.00388)	(9.75e-05)

Parweargla	0.955***	0.962***	0.0678
	(0.322)	(0.318)	(0.0439)
vil_liter		1.300**	0.0325*
		(0.645)	(0.0171)

Summary of Results

1. About 13% of 10-12 year old children in rural China needed glasses, but very few actually had them.

2. After about 8 months, glasses improved children's test scores by 0.16 to 0.22 standard deviations, which is equivalent to 0.33 to 0.50 years of additional education.

3. About one third of the children (or their parents) refused the offer of free glasses. Girls were more likely to refuse, but children with educated mothers and from wealthier households were more likely to accept/have glasses.

4. It is likely that similar results would hold for other developing countries, but we know of no other similar studies.