Poverty and Proximate Barriers to Learning: Vision Deficiencies, Vision Correction and Educational Outcomes in Rural Northwest China

July 17, 2008

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Keywords: China, children, education, vision, health, developing countries, poverty, eyeglasses.

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ABSTRACT

Few studies of educational barriers in developing countries have investigated the role of children's vision problems, despite the self-evident challenge that poor vision poses to classroom learning and the potential for a simple ameliorative intervention. We address this gap with an analysis of two datasets from Gansu Province, a highly impoverished province in northwest China. One dataset is the Gansu Survey of Children and Families (GSCF, 2000 and 2004), a panel survey of 2,000 children in 100 rural villages; the other is the Gansu Vision Intervention Project (GVIP, 2004), a randomized trial involving 19,185 students in 165 schools in two counties.

Results attest to significant unmet need for vision correction. About 11 percent of third to fifth graders in the GVIP and about 17 percent of 13 to 16 year-olds in the GSCF had diagnosed vision problems. Yet, just 1 percent of the GVIP sample and 7 percent of the GSCF sample wore glasses in 2004, and access to vision correction shows a sharp socioeconomic gradient in both datasets. Importantly, vision problems themselves are actually selective of higher socioeconomic status children and more academically engaged students, a finding that poses challenges to isolating the causal impact of glasses-wearing. Propensity score matching estimates based on the GSCF suggest a significant effect of glasses-wearing on standardized math and literacy tests, though not on language tests. Analysis of the GVIP intervention shows that those who received glasses were less likely to fail a class. While we cannot firmly rule out all sources of selectivity, findings are consistent with the commonsense notion that correcting vision supports learning.

The high level of unmet need for vision correction, together with evidence suggesting that wearing glasses supports learning, indicates the potential value of this simple intervention for students in developing country settings. The selectivity issues involved in the analysis indicate the need for further empirical studies that test the impact of vision correction on learning.

INTRODUCTION

Social scientists have long taken an interest in the mechanisms by which socioeconomic disadvantages in households translate to educational disadvantages for children. Researchers working from various frameworks have developed theories that emphasize socialization within families, the social networks and patterns of interaction that parents use to communicate with the school system, the cultural experiences and tools that aid children in their self-presentations to and interactions with teachers, and the different kinds of schools and teachers to which impoverished children have access (Buchmann and Hannum 2001; Hannum and Buchmann 2005). In high-poverty communities around the world, particularly those in low- and middle income countries, more proximate barriers also impede the day-to-day process of learning for children. For example, poverty can mean that children's studies are hindered by the inability to purchase supplies to take notes or do assignments. Children can go to school hungry or poorly nourished, and thus less able to focus.

One potentially important mechanism by which poverty may affect a child's day-to-day learning experiences is uncorrected vision problems. Bundy, Joshi, Rowlands & Kung (2003) report that about 10 percent of school-age children in developing countries have refraction errors, almost all of which can be corrected with properly fitted eyeglasses. Most children with refraction problems in low income countries do not have glasses. Few studies have investigated the impact of eyeglasses on school achievement, and none have investigated poor eyesight and educational achievement from a stratification perspective, by considering the social location of vision deficiencies and vision correction along with the impact of vision correction on outcomes. To address this gap, we ask first whether there are differences by child characteristics and by educational aptitude in the risk of poor vision, and in access to vision correction. We then investigate whether vision correction matters for educational outcomes—performance on standardized achievement tests and class failure.

FRAMEWORK AND HYPOTHESES

Despite the self-evident problems imposed by poor vision on classroom functioning and the potential for a relatively cheap and easy ameliorative intervention, there has been very little research on the impact of poor vision on students' academic performance.[1] One published study found large impacts of poor vision on primary school children in northeast Brazil: children with poor vision had a 10 percent higher probability of dropping out of school, an 18 percent higher probability of repeating a grade, and scored about 0.2 to 0.3 standard deviations lower on achievement tests (Gomes-Neto, Hanushek, Leite

& Frota-Bezzera, 1997). A straightforward set of hypotheses exists: the most economically disadvantaged children lack access to vision correction, and uncorrected vision is thus a mechanism by which economic deprivation translates to a poorer opportunity to learn.

Yet, while the logical relationship between economic deprivation and vision correction is straightforward, the relationship between poverty and risk of poor vision is more complex. In a number of studies, poor vision has been associated with higher levels of education and test scores—attributes in turn often associated with higher family socioeconomic status. For example, studies of youth and young adults in Singapore show a positive association between educational attainment and the prevalence and severity of myopia (Au Eong, Tay, & Lim, 1993; Tay, Au Eong, Ng & Lim, 1992). Similarly, a study of 18 year-old men in Denmark showed that those with myopia had higher levels of education and higher test scores than those without myopia (Teasdale, Fuchs, and Goldschmidt, 1988). This situation renders the potential impact of vision correction on educational inequality difficult to isolate, even if the expected impact of vision correction on achievement—the main question addressed in earlier studies by economists—is clear.

Vision problems afflict a significant minority of school-aged children in China. One study in Shunyi District, northeast of Beijing, found that 12.8 percent of children age 5 to 15 years had vision problems, of which 90 percent were due to refraction errors (Zhao, Pan, Sui, Munoz, Sperduto & Ellwein, 2000; Zhao, Mao, Luo, Li, Munoz & Ellwein, 2002). Only 21 percent of the children with vision problems had glasses (Zhao et al., 2000). Girls and older children had higher risk of myopia than boys and younger children: myopia was minimal among five year-olds, but rose to 37 percent among 15 year-old boys and 55 percent among 15 year-old girls (Zhao et al., 2000). The authors conclude that over 9 percent of children could benefit from glasses. A study of junior high school students in Yangxi County, a rural setting in western Guangdong, showed that myopia[2] affected 36.8 percent of 13-year-olds, with the rate increasing to 53.9 percent among 17-year-olds (He, Huang, Zheng, Huang & Ellwein, 2007, p. 374). Of children with impairment in both eyes, only 46.5 percent were wearing glasses (p. 376).

To our knowledge, the data collection projects reported on in the current study, namely a longitudinal survey of 2,000 rural children and a randomized trial involving 19,185 students in 165 schools in one of China's poorest provinces, are the first in China to link vision problems to educational achievement. The achievement effects of glasses provision in the randomized trial data have been analyzed in Glewwe, Park and Zhao (2006). Using a variety of estimation strategies, Glewwe and his colleagues showed that, after one year, provision of eyeglasses increased student performance by 0.15 to 0.30 standard deviations of the distribution of grades. The current paper complements Glewwe et al.'s (2006) report by presenting survey-based estimates utilizing standardized curriculum and literacy tests; by investigating the determinants of vision problems and access to vision correction; and by considering the relevance of vision correction as a protective factor in class failure.

DATA AND METHODS

Study Site and Data

The study site is Gansu Province, in northwestern China. In 2000, the most recent census year, Gansu's population was 25.6 million people, 76 percent of whom resided in rural areas (Gansu Bureau of Statistics, 2001). In 2004, almost one in five people ages 15 and above was not literate, compared to just over one in ten for China as a whole (National Bureau of Statistics, 2006a). Official estimates of rural per capita income for 2004 rank Gansu 30th out of 31 provinces—below Tibet and above Guizhou (National Bureau of Statistics, 2006b).

The GSCF is a longitudinal survey of 2000 children in 20 counties who were 9 to 12 years old when they were first interviewed in the year 2000 (GSCF-1), and who were re-interviewed at ages 13 to 16 in 2004 (GSCF-2). GSCF-1 sought to estimate the individual, household, school, and community determinants of educational outcomes in rural, underdeveloped areas. GSCF-2 maintained the education-related focus of GSCF-1, but added a significant health component. In all, 1918 target children from GSCF-1 were followed up at GSCF-2. However, about 13 percent of the children were not in school in 2004. Since this study focuses on the impact of vision problem and correction on school achievement, these cases are excluded from the sample. After eliminating those out of school and those with missing data, 1,630 cases are used in the analysis.

The 2004 data collection effort also included an add-on project, not part of the GSCF sample, called the Gansu Vision Intervention Project (GVIP). In this project, a randomized evaluation was conducted to measure the impact on education outcomes of providing eyeglasses to vision-impaired children. Two counties in Gansu Province were selected as study sites. All townships in each county were first ranked by rural income per capita. In each county, starting with the first two townships, one was randomly assigned to receive treatment, and the other, to serve as a control. Then, all primary schools in each township either all received treatment, or all served as controls. In the process of implementing the project, a few control townships mistakenly received glasses. These townships, as well as the treatment townships that were originally paired with them, were dropped from the current analysis. The final sample includes 19,185 students in grades 3 to 5 in the 2004-2005 academic year, in 165 schools.[3] After eliminating those with missing data, 18,817 cases are used in analysis.

Measurement

— Table 1 about here—

Poor vision. The first part of our analysis focuses on vulnerability to poor vision. Table 1 shows descriptive statistics on vision in both datasets. In 2004, in both the GVIP and the GSCF data, eye examinations were administered by Center for Disease Control personnel in Gansu. The examination employed was a domestic one used for screening purposes in schools by the Center for Disease Control. Scores ranged from 2.4 to 5.3 in the GVIP data and from 3.4 to 5.9 in the GSCF data. The Center for Disease Control and Prevention defines a 4.8 or lower score in either eye as a cutoff for requiring glasses, and that standard is used here to define the outcome variable *poor vision* in both datasets. Vision problems afflict a significant minority of children in rural Gansu. In the GVIP data, 11 percent of the children suffer from poor vision, and in the GSCF, 17 percent of the children do (see Table 1).

Vision correction. The second part of the analysis focuses on access to vision correction. The GVIP data and the GSCF data contain reports about whether children *wear glasses*. In the GVIP data, this information is reported by teachers involved in the project regarding children's status before the project provided glasses, and in the GSCF data, by children[4] themselves. In the GVIP data, 1 percent of all children wore glasses prior to the start of the project. In the GSCF data, 7 percent of all children wore glasses in 2004.[5]

The GVIP project also contains a variable *received glasses*, which refers to the children who accepted glasses as part of the GVIP project. Among all children in the GVIP data, 6 percent received glasses, a number that constitutes 45.6 percent of all children who had vision problems and 71.76 percent of children with vision problems in treatment townships.[6]

Educational Outcomes. Table 2 shows current and prior educational achievement measures in both datasets. In the GVIP data, we employ an outcome set to one if the child failed in math, Chinese, or science in spring 2005. Failure means receiving a grade of below 60 percent. Failure in these main subjects is significant, as it may lead to the student's repeating of the grade. In the sample, about 11 percent of all children had failed one or more subjects (see Table 2).

—Table 2 about here—

In the GSCF data, we use results from three tests administered as part of the project: *a literacy assessment,* a curriculum-based *math achievement test*, and a curriculum-based *language achievement test*. The literacy test had a mean of 20.5; a standardized version was used in the propensity score analysis. Math and language achievement tests had means of about 17 and 21, respectively. These tests were standardized by grade for the propensity score analysis, as they were grade-specific.

Prior engagement and achievement. In the GVIP, prior achievement is measured as a scale (average) of reported scores for math, science, and language for each semester in grades one and two. The scale has high internal reliability, with a Cronbach's Alpha score of .94. The average is about 82 for those with and without vision problems (see Table 2.)

In the GSCF, prior achievement is measured as *math score* (grade) and *language score* (grade) reported by teachers in the 2000 round of the survey. In the sample, the average math score is 74 and the average language score is about 73. To further control prior ability, we also add a *cognitive test score*. This standard test of cognitive ability, developed for the project at the Institute of Psychology at the Chinese Academy of Science, had a mean score of about 50.

—Table 3 about here—

Table 3 shows other background characteristics of children in the GVIP and GSCF, including a measure of child's own assessment of *math ability* and *language ability* in 2000. The ability variables are based on children's answers to questions "Compared with your classmates, what is your math level?", and "Compared with your classmates, what is your language level?" The original five-category responses, very poor, below average, average, above average, and excellent, are recoded into two categories for each question, with 1 for "above average" and "excellent" and 0 for the other categories. Using these definitions, about 37 percent of children viewed their language ability favorably, while 44 percent viewed their math ability in this way.

Socio-economic characteristics. In the GVIP data, we have just two simple variables measuring socio-economic status—*household head's years of schooling* and *head's non-farm* occupational status. On average, the household heads have 8.6 years of schooling, and 14 percent of them are not farmers (see Table 3). In the GSCF data, we employ measures of *mother's education*, *father's education*, and *logged household wealth*. On average, mothers have 4.2 years of schooling, while fathers have a little more than 7 years of schooling.

Other variables. In the GVIP data, we also include information on the *grade*, *sex*, and *ethnicity* of the child. All children in the analytic sample are in grades 3, 4, and 5 in primary school; 47 percent of children in the sample are girls, and 14 percent are minorities (see Table 3). Nearly all of the minority children are Tibetans. In the GSCF data, we include *age* and *sex* of the child. These variables were measured in 2000, so the average age of children was about 11 (15 in 2004), and 46 percent are female.

Methodological Approach

Our analysis employs logistic regressions of vision problems and access to eyeglasses with random effects for schools (in the GVIP data) or villages (in the GSCF data). We show in these analyses that there are considerable differences across social groups in the propensity to wear glasses. We employ two strategies to address this difference in propensity to wear glasses, in order to investigate the impact of glasses-wearing on achievement.

First, for analyses of the GSCF data, we focus on a sample of only those children with poor vision in 2004. This strategy eliminates bias associated with selection into the status of poor vision. Next, using this subsample, we employ propensity score matching to address selection bias associated with gaining access to glasses. With a propensity score matching approach, we assume that pertinent differences between those with and without glasses can be captured by observable variables, and select from the non-treated a "control group" in which the distribution of observed variables is as similar as possible to that in the treated group (glasses-wearers). We use the *psmatch2* program in Stata to estimate propensity scores for glasses-wearing, with kernel matching. We use logit models for estimation of propensity scores. In the models, we included all predictor variables that were part of our analysis of glasses-wearing, and we imposed a common support structure (for a straightforward discussion of the implications of model choice, matching choice, and common support, see Caliendo and Kopeinig, 2008). Further investigation showed that all significant differences in predictors in the original sample were eliminated in the matched sample. We present bootstrapped estimates of average treatment effects on the treated, with standardized literacy, language, and math scores as outcomes.

Second, using the randomized intervention data—the GVIP data—we present logistic regressions of class failure to estimate the impact of receiving glasses on school progress, at the margins. We include random effects for schools and control for background factors that might be associated with acceptance of the randomized offer of treatment and with class failure.[7]

RESULTS

Analysis of Poor Vision

—Figure 1 about here—

Children who can't see what teachers are writing on the board and can't do homework due to vision problems face evident barriers to learning. In the GSCF, a significant fraction of children themselves report experiencing vision-related barriers to learning. Almost one in five children reported having problems reading the blackboard, and 12 percent reported having difficulty doing homework because of eye problems. Nearly a quarter of students (23 percent) complained that their eyes hurt while doing homework because of poor light conditions at home (Figure 1).

—Table 4 about here—

Turning to measured vision problems, in the GVIP sample, as noted above, about 11 percent of children were diagnosed with poor eyesight. Multivariate analyses show that children who performed better early on in school, who were in non-farming households, who were in higher grades, and who were girls had significantly higher risk of poor vision (see Table 4). Alone or controlling for all other displayed variables in model 4, a one standard deviation increase in the prior achievement measure is associated with about a 6 percent increase in the odds of poor vision ($1.008^{8.06}$=1.06). Compared to children in farming households, odds of poor vision for children of parents in non-farming households were about 20 percent higher in the most conservative multivariate specification, as shown in model 4 (100*[1.195-1]). In the same specification, boys' odds of poor vision were about 23 percent lower than girls' (100*[1-.766]), and each higher grade increased odds of poor vision by about 53 percent (100*[1.531-1]). Thus, the GVIP findings suggest that there is an elevated chance of poor eyesight among children who perform well, among children who are older and who are girls, and among higher socioeconomic status children, as indicated by non-farm family status. There is no significant association with ethnicity or head's education, in bivariate models or net of other controls in the models shown in Table 4.

—Table 5 about here—

The GSCF project offers more detailed variables measuring children's background. In the GSCF data, simple specifications show that mother's education, child's higher self-reported Chinese and math ability in 2000, and age were significant predictors of subsequent vision problems (see Table 5, models 1 to 5). Wealth, prior performance in math and language, prior cognitive development score, and sex are not significant here, though the odds-ratio for sex, like in the case of the GVIP, suggests lower odds of poor vision for boys. In the full model, model 6, mother's education, Chinese and math ability, and age were significant predictors. For example, each additional year of maternal education is associated with an increase of 4.6 percent in odds of a vision problem diagnosis (100*[1.046-1]). Reporting a high level of math ability early on is associated with 43 percent higher odds of poor eyesight, relative to reporting a lower ability (100*[1.429-1]). For Chinese ability, the figure was 34 percent (100*[1.34-1]). Finally, each year of age is associated with a 25 percent increase in odds of a vision problem diagnosis (100*[1.254-1]).

Overall, although the GVIP and GSCF offer different measures, neither suggests that the most socioeconomically disadvantaged are at particularly high risk of poor eyesight. In fact, analyses of both datasets suggest that there is a tendency for vision problems to be greater among higher socio-economic status children and among children who are more educationally engaged. This finding is consistent with available research conducted elsewhere.

Access to Vision Correction

In the GVIP sample, just one percent of all children reported wearing glasses before the project.[8] However, there is a big gap between farming and non-farming households. In the full sample, about 0.8 percent of children in households headed by farmers were reported as wearing glasses prior to the project, compared to 2.8 percent of children in households headed by non-farmers (our calculations, not shown). Among children with poor eyesight, comparable figures were 1.95 and 7.3 percent (our calculations, not shown).

—Table 6 about here—

Table 6 shows results from a series of logistic regression models of glasses-wearing in the GVIP sample. Models 1 to 4 show that prior performance, head's non-farm status, minority status, and higher grades are associated with glasses-wearing. Model 5 re-estimates model 4 with only students who have poor eyesight in the sample. Here, only non-farm status has an effect on wearing glasses. In the sample restricted to children diagnosed with poor eyesight, the odds of glasses-wearing were 2.9 times as high for those in non-farm households, compared to the odds in farming households.

—Table 7 about here—

Logistic regression analysis of glasses-wearing in the GSCF shows that without adjusting for other factors, there is a marginally significantly higher odds of wearing glasses for children with higher test scores (in math and in the cognitive test) (model 1), and significant positive effects for children of better educated parents (model 2), wealthier children (model 3) and children reporting better academic ability (in Chinese) (model 4). There is no significant difference by sex. Age is strongly related to wearing glasses (model 5). In Model 6, with all predictors from models 1 to 5 controlled, mother's education, Chinese ability, family wealth and children's age significantly predict glasses wearing, though mother's education and Chinese ability are only marginally significant in this specification. Model 7 re-estimates Model 6 on a sample of only those with poor eyesight. In this much smaller sample, the only variables that matter for glasses-wearing are wealth and age. Wealth differences are striking. In the raw data, about 4 percent of children in the bottom wealth quintile (measured in the earlier survey wave) wore glasses, as did about 9 to 11 percent in the top two wealth quintiles (our calculations). Among children with poor eyesight, the corresponding range was 10 percent for children in the poorest quintile of household wealth to over one-third in the top two quintiles.

Overall, findings show that wealthier children have better access to glasses. They also show that children who engage academically early on are more likely to be the beneficiaries of glasses, though much of this effect may occur through their higher likelihood of poor vision.

Impact of Glasses on Achievement

We know from earlier work that has investigated various estimates, including difference-in-difference estimates and instrumental variable approaches, that providing glasses to children in the GVIP sample had an impact on learning, as measured by grades standardized at the school level (Glewwe et al., 2006). Here, we complement this work with GSCF estimates, which can be produced based on standardized achievement tests rather than grades. However, the impact of glasses is harder to convincingly isolate in the GSCF survey, because of selection issues described in the preceding sections.

—Table 8 about here—

To address selectivity, we use model 7 in Table 7 to estimate propensity scores of wearing glasses, and then present estimates of the average treatment effect on the treated for the matched samples produced by this exercise. Results are shown in Table 8. For the literacy outcome, the average treatment effect on the treated is .43 standard deviations. For the language achievement outcome, the effect is not significant. For the math achievement outcome, the effect is .27 standard deviations. We can't completely rule out the possibility that our strategy for matching the treatment and control samples has not fully accounted for pertinent differences in unmeasured variables. However, our finding of significant effects of glasses-wearing on literacy and math scores are consistent with significant positive effects for grades found by Glewwe, Park and Zhao (2006) using an experimental design.

The Impact of Glasses on Class Failure

—Table 9 about here—

Finally, we consider whether glasses' effect on achievement matters at the margins, for failure. Table 9 shows results from a logistic regression analysis of failure in math, Chinese, or science, with a positive outcome indicating failure in at least one of these subjects. Column 1 shows an analysis using the full sample, and column 2 shows the same analysis estimated on a sample of children with poor eyesight. In the first case, the odds of failing a class are reduced by about 44 percent (100*[1-.559]), and in the second case, the odds of failing a class are reduced by 35 percent (100*[1-.646]) among children who received glasses from the project. The smaller reduction among children with poor eyesight is expected, given that these children are likely to have been stronger students earlier on.[9] Other results suggest that males, early high achievers, and those in a higher grade are less likely to fail. Among those with poor eyesight, children in non-farming households were less likely to fail.

Summary

Results from these analyses show that a significant fraction of children in Gansu face vision problems, and few have access to glasses. Moreover, overall or just among those with poor vision, access to vision correction is strongly associated with a child's socioeconomic background—farming versus non-farming status and wealth. While access to glasses is lowest among the poorest, vision problems themselves are actually selective of better-off children and more academically engaged students. Our analyses suggest that vision correction matters for standardized literacy and math tests, and for the likelihood of failing classes.

CONCLUSIONS

In low- and middle- income countries, economic deprivation often translates to proximate barriers to day-to-day educational functioning for children within the school system. Children in Gansu themselves report that poor eyesight impedes their educational experience, and our findings are consistent with this perception. About 11 percent of third to fifth graders in the GVIP and about 17 percent of 13 to 16 year-olds in the GSCF had measured vision problems. Yet, just 1 percent of the GVIP sample and 7 percent of the

GSCF sample wore glasses in 2004, and access to vision correction shows a sharp socioeconomic gradient in both datasets.

Significantly, vision problems themselves are selective of better-off children and more academically engaged students, and this selectivity makes isolating the causal impact of glasses-wearing a difficult task. Our propensity score matching estimates based on the GSCF suggest a significant effect of glasses-wearing on standardized math and literacy tests, though not on language tests. Analysis of the GVIP intervention data shows that those who received glasses were less likely to fail a class. While we cannot firmly rule out all sources of selectivity in glasses-wearing in the GSCF or in accepting glasses in the GVIP, our findings are consistent with the commonsense notion that correcting vision supports learning.

Thus, results attest most clearly to a significant unmet need for vision correction. This finding is consistent with Bundy et al.'s (2003) characterization of the situation of children in developing countries more broadly. This need, together with evidence suggesting that wearing glasses supports learning, underscores the potential value of glasses provision as an aid to educational functioning for students in impoverished areas in developing country settings. At the same time, together with earlier findings, the academic and socioeconomic selectivity in vision problems documented here suggests that vision interventions will be unlikely to target the most impoverished, most educationally vulnerable children in these areas. Selectivity issues also indicate the need for further empirical studies that test the impact of vision correction on learning outcomes.

REFERENCES

Au Eong, K. G., T. H. Tay & M. K. Lim. 1993. "Education and Myopia in 110,236 Young Singaporean Males." *Singapore Medical Journal* 34:489-92.

Buchmann, Claudia & Emily Hannum. 2001. "Education and Stratification in Developing Countries: A Review of Theories and Research." *Annual Review of Sociology* 27:77-102.

Bundy, Donald, Arun Joshi, Megan Rowlands & Yung-Ting Kung. 2003. "EnVISIONing Education in Low Income Countries." The World Bank. Washington, D.C.

Caliendo, Marco & Sabine Kopeinig. 2008. "Some Practical Guidance For The Implementation Of Propensity Score Matching." *Journal of Economic Surveys* 22 (1): 31-72.

Gansu Bureau of Statistics. (2001). "Public Report on the Fifth Census—Gansu" Report issued April 5, 2001. (electronic version, http://www.stats.gov.cn/tjgb/rkpcgb/dfrkpcgb/t20020331_15402.htm, accessed April 10, 2004).

Glewwe, P., H. Jacoby, & E. King. (2001). "Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis." *Journal of Public Economics* 81 (3):345-368.

Glewwe, P. A. Park & M.Zhao. (2006). "The Impact of Eyeglasses on the Academic Performance of Primary School Students: Evidence from a Randomized Trial in Rural China." Retrieved June 21,2008 (http://www.apec.umn.edu/faculty/frunge/Minn-ItalyConf2006/Glewwe,Paul.pdf)

Gomes-Neto, J. B., E. A. Hanushek, R. H. Leite & R. C. Frota-Bezzera. 1997. "Health and Schooling: Evidence and Policy Implications for Developing Countries." *Economics of Education Review* 16:271-82.

Hannum, Emily & Claudia Buchmann. 2005. "Global Educational Expansion and Socio-Economic Development: An Assessment of Findings from the Social Sciences." *World Development* 33:333-54.

He, Mingguang, Wenyong Huang, Yingfeng Zheng, Li Huang & Leon B. Ellwein. 2007/2. "Refractive Error and Visual Impairment in School Children in Rural Southern China." *Ophthalmology* 114:374,382.e1.

National Bureau of Statistics (China). 2006a. "China Statistics Yearbook 2005, Table 4-12: Illiterate and Semi-Literate Population Aged 15 and Over by Sex and Region (2004)." Beijing: National Bureau of Statistics (China), Retrieved 6/22, 2006 (http://www.stats.gov.cn/tjsj/ndsj/2005/html/D0412E.xls).

National Bureau of Statistics (China). 2006b. "China Statistics Yearbook 2005, Table 10-21: Per Capita Net Income of Rural Households by Region." Beijing: National Bureau of Statistics (China), Retrieved 5/28, 2006 (http://www.stats.gov.cn/tjsj/ndsj/2005/html/J1021e.xls).

Tay, M. T., K. G. Au Eong, C. Y. Ng & M. K. Lim. 1992. "Myopia and Educational Attainment in 421,116 Young Singaporean Males." *Annals of the Academy of Medicine, Singapore* 21:785-91.

Teasdale, T. W., J. Fuchs & E. Goldschmidt. 1988. "Degree of Myopia in Relation to Intelligence and Educational Level." *Lancet* 2:1351-4.

United Nations Development Programme (UNDP). (2000). *Human development report, 2000*. New York: Oxford University Press.

Zhao, Jialiang, Jin Mao, Rong Luo, Fengrong Li, Sergio R. Munoz & Leon B. Ellwein. 2002/11. "The Progression of Refractive Error in School-Age Children: Shunyi District, China." *American Journal of Ophthalmology* 134:735-43.

Zhao, Jialiang, Xiangjun Pan, Ruifang Sui, Sergio R. Munoz, Robert D. Sperduto & Leon B. Ellwein. 2000/4. "Refractive Error Study in Children: Results from Shunyi District, China." *American Journal of Ophthalmology* 129:427-35.

NOTES

[1] However, there are new, coordinated efforts to collect global comparable data on vision problems in children. Refractive Error Study in Children (RESC) surveys have been implemented in a standardized way at eight sites worldwide to provided unprecedented comparative data on the prevalence of refractive error in school-age children (for a description and list of studies, see He et al., 2007).

[2] Myopia is defined in the study as follows: spherical equivalent, −0.50 diopters [D] or more in either eye.

[3] For detailed description of the sampling procedure, please see Glewwe, Park and Zhao (2006).

[4] The GSCF data includes information on children's glasses wearing from both target children, their homeroom teachers, and from a household questionnaire, which was usually answered by fathers. There are some discrepancies among the different groups. Among children who reported themselves as wearing glasses, 80 percent were also reported as wearing glasses by their fathers, but only about 47 percent were reported as such by homeroom teachers, which may be due to the fact that children may not wear their glasses all the time.

[5] It is likely that rates are higher in the GSCF data because children are older, and age is associated with poor vision. Children in the GSCF are ages 13 to 16, and mainly in junior high school. Children in the GVIP analytic sample are in grades 3 to 5.

[6] We have only simple information about refusals. Of the 30 percent of children offered glasses who did not receive them, about one quarter reportedly refused due to parents not wanting to accept glasses, and about 18 percent were due to children not wanting to accept glasses. About 14 percent of those who did not accept glasses reportedly did so because they could not adjust to glasses, and another 16 percent said that they did not accept because of eye disease. About 5 percent did not accept the offer because an optometrist was not available, and about 7 percent had vision problems that were not correctable with glasses or were otherwise handicapped.

[7] We do not investigate class failure in the GSCF data due to sample size limitations.

[8] A considerable number of the children wearing glasses prior to the start of the project did not have vision test results that qualified them for receiving eyeglasses as part of the project.

[9] We control for prior achievement here, but the control is unlikely to be complete.

FIGURE CAPTION

Figure 1. Proportion of Children Reporting Various Vision Problems.

TABLES AND FIGURES

Table 1. Vision Descriptives

	Mean or Proportion	SD	95% Conf. Interval Lower	Upper	N
GVIP:					
Vision Problem Diagnosis, 2004*	0.11	0.31	0.10	0.11	18817
Wearing Glasses before Project	0.01	0.10	0.01	0.01	18817
Received Glasses from Project	0.06	0.23	0.05	0.06	18817
GSCF:					
Vision Problem Diagnosis, 2004*	0.17	0.37	0.15	0.18	1630
Wears Glasses, 2004	0.07	0.26	0.06	0.09	1630

[a]Vision problem diagnosis is coded as "1" if either eye has a vision score worse than the 4.8 cutoff (in 2004), else "0".

Table 2. Prior and Current Achievement

All Cases		Mean			(SD)		N
GVIP:	Fail Rate (Proportion)	0.11			0.31		18817
	Prior Achievement Scale*	82.4			8.06		18817
GSCF:	Literacy Test Score	20.49			6.05		1502
	Achievement Test: Math	17.24			13.03		1568
	Achievement Test: Chinese	20.94			10.97		1568
	Math Grade in 2000	74.23			14.42		1630
	Chinese Grade in 2000	72.56			13.13		1630
	Cognitive Test in 2000	50.13			19.84		1630

By Vision Problem Diagnosis[a]		With Vision Problems			Without Vision Problems		
		Mean	(SD)	N	Mean	(SD)	N
GVIP:	Fail Rate (Proportion)	0.10	0.3	2030	0.11	0.31	16787
	Prior Achievement Scale	82.26	8.13	2030	82.45	8.07	16787
GSCF:	Literacy Test Score***	22.10	5.69	245	20.17	6.06	1257
	Achievement Test: Math***	21.15	13.71	263	16.45	12.76	1305
	Achievement Test: Chinese	21.51	10.31	263	20.82	11.10	1305
	Math Grade in 2000***	76.33	13.53	272	73.82	14.56	1358
	Chinese Grade in 2000**	74.42	11.77	272	72.19	13.36	1358
	Cognitive Test in 2000**	52.40	19.44	272	49.68	19.90	1358

By Glass-Wearing Status (2004)		Wearing Glasses Before Project			Not Wearing Glasses Before Project		
GVIP:		Mean	(SD)	N	Mean	(SD)	N
	Fail Rate***	0.05	0.22	199	0.11	0.31	18617
	Prior Achievement Scale***	85.15	7.46	199	82.40	8.06	18617
GSCF:		Wearing Glasses			Not Wearing Glasses		
	Literacy Test Score***	23.99	4.90	103	20.23	6.04	1399
	Achievement Test: Math***	26.12	16.00	117	16.53	12.50	1451
	Achievement Test: Chinese	22.06	11.55	117	20.85	10.92	1451
	Math Grade in 2000***	79.05	12.13	119	73.85	14.52	1511
	Chinese Grade in 2000***	76.32	10.42	119	72.26	13.28	1511
	Cognitive Test in 2000***	55.03	19.44	119	49.74	19.83	1511

Note: *Significant mean difference across categories by T-test, .01-***; .05-**; .01-*

[a]Vision problem diagnosis is coded as "1" if either eye has a vision score worse than the 4.8 cutoff (in 2004), else "0".

Table 3: Sample Background Characteristics

GVIP:	Among All Cases			Among Children with Vision Problems*			Among Children Who Wore Glasses before the Project		
	Mean (or Proportion)	(SD)	N	Mean (or Proportion)	(SD)	N	Mean (or Proportion)	(SD)	N
Household Head's Education (Years)	8.62	2.26	18817	8.43	2.22	2030	9.40	2.79	199
Non-farm Household Head (1=Yes)	0.14	0.35	18817	0.11	0.32	2030	0.39	0.49	199
Child Gender (1=Male)	0.53	0.50	18817	0.47	0.50	2030	0.50	0.50	199
Ethnicity (1=Minority)	0.14	0.35	18817	0.12	0.32	2030	0.25	0.43	199
Grade 3	0.33	0.47	18817	0.22	0.42	2030	0.18	0.38	199
Grade 4	0.33	0.47	18817	0.31	0.46	2030	0.35	0.48	199
Grade 5	0.34	0.47	18817	0.47	0.50	2030	0.47	0.50	199
GSCF:	Among All Cases			Among Children with Vision Problems*			Among Children Who Wore Glasses in 2004		
	Mean (or Proportion)	(SD)	N	Mean (or Proportion)	(SD)	N	Mean (or Proportion)	(SD)	N
Father's Education (Year)	7.04	3.51	1630	7.24	3.53	272	8.22	3.21	119
Mother's Education (Year)	4.18	3.48	1630	4.68	3.62	272	5.53	3.73	119
Family Wealth in 2000 (RMB)	14672.78	16092.72	1630	14578.63	15824.53	272	16952.67	14418.45	119
Number of Children in Family	2.32	0.72	1630	2.33	0.70	272	2.38	0.70	119
Child Gender (1=Male)	0.54	0.50	1630	0.50	0.50	272	0.50	0.50	119
Child Age in 2000	10.95	1.07	1630	11.14	1.06	272	11.50	1.07	119
Child Reported Good Language Ability in 2000	0.37	0.48	1630	0.44	0.50	272	0.47	0.50	119
Child Reported Good Math Ability in 2000	0.44	0.50	1630	0.51	0.50	272	0.52	0.50	119

[a]Vision problem is coded as "1" if either eye has a vision score worse than the 4.8 cutoff (in 2004), else "0".

Table 4. Random Effects Logistic Regression Analysis of Poor Eyesight Diagnosis, GVIP Data

	1	2	3	4
	OR/(SE)	OR/(SE)	OR (SE)	OR (SE)
Prior Achievement Scale	1.008**			1.007*
	(0.004)			(0.004)
Household Head's Education (Years)		0.996		0.998
		(0.013)		(0.013)
Non-farm Household Head		1.189*		1.195**
		(0.109)		(0.111)
Sex (1=Male)			0.752***	0.766***
			(0.037)	(0.038)
Ethnicity (1=Minority)			0.967	0.987
			(0.092)	(0.096)
Grade				1.531***
				(0.047)
/lnsig2u	-0.467	-0.467	-0.360	-0.431
	(0.129)	(0.126)	(0.130)	(0.128)
Log-Likelihood	-6,080.46	-6,081.92	-6,065.25	-5,963.61

Note: .01 - ***; .05 - **; .1 - *;

Table 5. Random Effects Logistic Regression Analysis of Poor Eyesight Diagnosis, GSCF Data

	1	2	3	4	5	6
	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)
Math Grade in 2000	1.011					1.008
	(0.009)					(0.009)
Chinese Grade in 2000	1.001					0.997
	(0.010)					(0.010)
Cognitive Test in 2000	1.005					1.003
	(0.004)					(0.004)
Mother's Education (Years)		1.044*				1.046*
		(0.024)				(0.025)
Father's Education (Years)		0.998				0.982
		(0.022)				(0.023)
Logged Wealth			1.077			1.047
			(0.075)			(0.076)
Child Reported Good Chinese				1.348*		1.34*
Ability in 2000				(0.213)		(0.218)
Child Reported Good Math Ability				1.417**		1.429**
in 2000				(0.222)		(0.231)
Sex (1=Male)					0.85	0.849
					(0.122)	(0.125)
Age					1.227***	1.254***
					-0.084	(0.088)
/lnsig2u	-0.322	-0.323	-0.2882023	-0.253	-0.324	-0.2915809
	(0.272)	(0.272)	(0.268)	(0.269)	(0.270)	(0.270)
Log-Likelihood	-702.52	-704.11	-705.44	-699.20	-700.90	-698.60

Note: .01 - ***; .05 - **; .1 - *;

Table 6. Random Effects Logistic Regression Analysis of Wearing Glasses, GVIP Data

	1	2	3	4	5
	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)
Prior Achievement Scale	1.031***			1.025**	1.013
	(0.011)			(0.012)	(0.021)
Household Head's Education		1.045		1.032	1.019
(Years)		(0.034)		(0.034)	(0.072)
Non-farm Household Head		3.062***		2.936***	2.945***
		(0.588)		(0.594)	(1.119)
Sex (1=Male)			0.893	0.901	0.879
			(0.129)	(0.132)	(0.271)
Ethnicity (1=Minority)			1.648**	1.471*	1.362
			(0.352)	(0.321)	(0.647)
Grade				1.661***	1.266
				(0.159)	(0.259)
/lnsig2u	0.745	0.758	0.782	0.852	0.537
	(0.204)	(0.208)	(0.208)	(0.199)	(0.304)
Log-Likelihood	-954.20	-944.98	-957.15	-925.23	-212.12
Estimation Sample	Full	Full	Full	Full	Poor Eyesight

Note: .01 - ***; .05 - **; .1 - *;

Table 7. Random Effects Logistic Regression Analysis of Wearing Glasses in 2004, GSCF Data

	1	2	3	4	5	6	7
	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)	OR/(SE)
Math Grade in 2000	1.025*					1.022	1.017
	(0.014)					(0.014)	(0.021)
Chinese Grade in 2000	1.000					0.992	0.99
	(0.015)					(0.015)	(0.024)
Cognitive Test in 2000	1.011*					1.007	1.004
	(0.005)					(0.006)	(0.010)
Mother's Education (Years)		1.077**				1.057*	1.072
		(0.034)				(0.035)	(0.055)
Father's Education (Years)		1.082**				1.055	1.04
		(0.036)				(0.036)	(0.054)
Logged Wealth			1.354***			1.272**	1.317*
			(0.127)			(0.126)	(0.203)
Child Reported Good Chinese				1.592**		1.504*	1.24
Ability in 2000				(0.354)		(0.349)	(0.481)
Child Reported Good Math Ability				1.32		1.199	1.325
in 2000				(0.291)		(0.277)	(0.515)
Sex (1=Male)					0.813	0.801	1.068
					(0.166)	(0.168)	(0.359)
Age					1.683***	1.718***	1.519**
					(0.169)	(0.176)	(0.253)
/lnsig2u	-0.181	-0.307	-0.136	0.011	-0.172	-0.401	-0.008
	(0.369)	(0.384)	(0.359)	(0.342)	(0.373)	(0.419)	(0.635)
Log-Likelihood	-404.50	-403.66	-406.90	-407.49	-397.32	-378.19	-141.35
Estimation Sample	Full	Full	Full	Full	Full	Full	Poor Eyesight

Note: .01 - ***; .05 - **; .1 - *;

Table 8. Propensity Score Matching Results for Eyeglass Provision, GSCF (Sample is Children with Poor Eyesight Only)

	Treatment N	Control N	ATT	Bootstrapped Std. Err.	z	Sig	95% Confidence Interval Lower Bound	Upper Bound
Standardized Literacy Assessment	64	181	0.433	0.097	4.49	0.000	0.244	0.622
Standardized Language Curriculum Test	71	190	0.109	0.115	0.95	0.343	-0.117	0.335
Standardized Mathematics Curriculum Test	71	190	0.274	0.116	2.36	0.018	0.047	0.501

Propensity score equations are same as Model 7 in Table 7.

Kernel matching is used.

Table 9. Logistic Regression Analysis of Class Failure, GVIP

	1	2
	OR/(SE)	OR/(SE)
Received Glasses	0.559***	0.646*
	(0.074)	(0.153)
Prior Achievement Scale	0.892***	0.901***
	(0.004)	(0.010)
Household Head's Education	0.980	0.993
(Years)	(0.014)	(0.047)
Non-farm Household Head	0.941	0.394**
	(0.112)	(0.166)
Sex (1=Male)	0.896**	0.728*
	(0.049)	(0.133)
Ethnicity (1=Minority)	0.907	0.570
	(0.106)	(0.263)
Grade	0.830***	0.757**
	(0.028)	(0.086)
Received Glasses X Prior Achievement		
Received Glasses X Ethnicity		
/lnsig2u	0.348	0.673
	(0.140)	(0.260)
Log-Likelihood	-4,952.26	-529.10
Sample	Full	Poor Eyesight

Note: .01 - ***; .05 - **; .1 - *;

Figure 1. Proportion of Children Reporting Various Vision Problems