Effect of a Local Vision Care Center on Eyeglasses Use and School Performance in Rural China: A Cluster Randomized Clinical Trial

Impact of a Local Vision Care Center on Glasses Use and School Performance in Rural China: A Cluster-Randomized Controlled Trial

Yue Ma, PhD;[1] Nathan Congdon, MD, MPH;[2, 3, 4] Yaojiang Shi, PhD;[1*] Ruth Hogg, PhD;[3] Alexis Medina, MA;[5] Matthew Boswell, MA;[5] Scott Rozelle, PhD;[5] Mony Iyer, MBA[6]

[1] Center for Experimental Economics in Education, Shaanxi Normal University, Xi'an, Shaanxi, China 710119;
[2]State Key Laboratory of Ophthalmology and Division of Preventive Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China 510060;
[3]Centre for Public Health, School of Medicine, Dentistry and Biomedical sciences, Queen's University Belfast; Belfast UK
[4]Orbis International, New York, USA
[5]Rural Education Action Program, Freeman Spogli Institute for International Studies, Stanford University, Palo Alto, CA, USA 94305.
[6] OneSight, Mason, Ohio, USA 45040

[*]**Address for correspondence:** Prof Yaojiang Shi, shiyaojiang7@gmail.com; Center for Experimental Economics in Education, Shaanxi Normal University, 620 Chang'an Rd West, Chang'an District, Xi'an, Shaanxi, China 710119

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Key Points:

Question: What is the impact of a county-based vision center on glasses use and school performance among primary school children in rural China?

Findings: Results from a Cluster Randomized Controlled Trial showed that provision of free glasses improved children's academic performance and spectacles use. Overall, seeing more clearly results in better academic performance.

Meaning: A county-based vision center is an effective way to address vision care problems and improve school performance in rural China.

Abstract

Importance: Visual impairment is common among rural Chinese children, but fewer than one third of children with poor vision own and wear glasses.

Objective: To study the effect of rural hospital-based Vision Centers on academic performance, ownership of glasses and glasses wear in rural Chinese children.

Design: Cluster-randomized, investigator-masked, controlled trial.

Setting: We established a Vision Center in the government Hospital of Yongshou County, a nationally-designated poor county in rural Shaanxi Province, western China, capable of providing refractive services. All rural primary schools (n = 31) in Yongshou County were invited to participate.

Participants: All children in Grades 4 - 6 with uncorrected visual acuity ≤6/12 in either eye. All were Han Chinese. 50.1% were female.

Interventions: After teacher-led vision screening early in the school year (September-October 2014), schools were randomly assigned to either: Early Referral (December 2014-February 2015) to the Vision Center for refraction and free glasses if needed; and Late Referral (March-June 2015) for the identical intervention.

Main Outcomes and Measures: Score on a study-administered mathematics test (June 2015) adjusted for baseline score (primary outcome); self-reported glasses ownership and wear at examination (June 2015) (secondary outcomes).

Results: Among 2,613 children, 1200 (45.9%) met vision criteria. Among these, 543 (45.3%) and 657 (54.7%) were randomized to Early and Late Screening respectively, and 433 (79.7%) and 516 (78.5%) completed the study. Among eligible children, only 28% owned glasses at baseline. The adjusted effect on test score comparing Early and Late groups was 0.25 SD (95% Confidence Interval [CI] 0.01 to 0.48, p = 0.04), the point estimate being equivalent to a half-semester of additional learning. Closeout glasses ownership and wear were 80% (347/433) and 75% (326/433) in the Early group and 61% (317/516, P = 0.008) and 55% (286/516, P = 0.03) in the Late.

Conclusions and Relevance: Earlier provision of free glasses improved children's academic performance and spectacles wear. These findings suggest a county hospital-based vision center may be an effective way to improve children's educational opportunities in rural China.

Impact of a Local Vision Care Center on Glasses Use and School Performance in Rural China: A Cluster-Randomized Controlled Trial

A series of World Health Organization (WHO)-supported studies suggests that approximately 10 to 20 percent of school-aged children in low and middle income countries suffer from refractive error.[1-4] Nearly half of children worldwide who are visually impaired from this cause live in China.[5] Refractive error can be detected with simple vision screening and safely corrected[6] with accurate glasses.[1] Despite the existence of this relatively simple intervention, in low-resource settings including rural China, less than one third of children with poor vision own or wear glasses.[7-9]

What accounts for the low rates of glasses use in these settings? Cost is not the main barrier to access: our findings suggest that only the poorest families in rural China cannot afford a pair of glasses.[10] In fact, many families are willing to spend money on glasses for their children, even in poor areas.[11]

A primary reason for the low rate of glasses ownership may be lack of access to vision care services.[12] An estimated 625 million people are blind or visually-impaired globally for this reason. Underserved areas, including rural China, lack necessary facilities, infrastructure and equipment, and skilled practitioners.[13-15]

Vision Centers are one of the most popular strategies for non-governmental organizations (NGOs) and governments attempting to overcome barriers to accessing high-quality glasses.[13,16,17] Vision Centers are long-term facilities, providing affordable eye care services for local communities. They tend to target people with uncorrected refractive error and offer a range of services that may include eye examinations, refraction and optical dispensing.[13,16-18] Despite their popularity, there is little published evidence evaluating the quality and impact of refractive services they deliver.

We carried out a Randomized Controlled Trial (RCT) to measure the impact of Vision Centers on glasses ownership, use and school performance among children. We hypothesized that access to the optometric services provided by the Vision Center earlier rather than later in the school year would lead to significantly greater levels of glasses ownership, use, and school performance. More specifically, we hypothesized that by improving access to glasses, the Vision Center would lead to an increase in glasses ownership, which we hoped would carry over into an increase in glasses use (wear). We further hypothesized that increases in glasses ownership and wear would lead to improvements in students' educational outcomes.

In part to help ensure that increased glasses ownership would carry over into glasses wearing, we involved children's primary school teachers in the screening process. Our hypothesis was that teachers would provide extra nudges to students that might improve rates of glasses wear. Indeed, randomized trials conducted elsewhere have shown that involving teachers in school-based programs can significantly increase rates of glasses wear.[19] We additionally hypothesized that greater compliance with glasses wear would yield a larger observed effect size on educational outcomes. Previous randomized trials have shown that provision of spectacles to children significantly improves academic performance, even in the face of relatively low compliance with glasses wear.[8]

Methods

Ethical approval for this study was provided by the Stanford University Institutional Review Board (IRB) (Protocol ID 24847). Permissions were received from the local Boards of Education in the study area, and the principals of all participating schools. All participating children gave oral assent prior to baseline data collection, and legal guardians gave written consent for their children's involvement in the study. The principles of the Declaration of Helsinki were followed throughout.

Setting

We established a Vision Center in the local government hospital of Yongshou, a nationally-designated poor county in rural Shaanxi Province. Yongshou County has a total population of 186,100 and a per capita Gross Domestic Product (GDP) of US$4308, ranking it 88th out of 107 counties in Shaanxi Province.[20] Prior to the establishment of the Vision Center, there was no public provider of refractive services in the county, and the three private providers were all located in the county seat.

Vision Center set-up and staff training

The Vision Center was established in collaboration with the Shaanxi Province Ministry of Education and the prefectural Bureau of Education overseeing Yongshou County. The government's goal was for Yongshou to act as a model county for all of Shaanxi Province, with eventual upscaling of the program to provide vision care to all rural children in the province in grades 4 to 6 (ages 10 to 12 years approximately).

The Yongshou County Hospital selected three employees (one ophthalmologist and two ophthalmic nurses) to staff the Vision Center. These individuals underwent formal refraction training at China's top refractionist training program at Zhongshan Ophthalmic Center (ZOC) in Guangzhou, China. The training lasted one month, from September to October 2014. At the conclusion of the program, all three employees received national certification as qualified refractionists and opticians from China's Ministry of Labor and Social Security. Subsequent to this formal training, the Yongshou staff members underwent one month of supervised practical training in their home county, during which time each staff member screened and refracted hundreds of children from local schools, and underwent practical instruction in glasses dispensing. A consultant from Brien Holden Vision Institute provided management training, including inventory control and record-keeping.

Sampling, eligibility criteria

We enrolled all rural primary schools in Yongshou County, and, within each school, examined all children in grades 4-6. Children were eligible for participation if they had an uncorrected visual acuity of ≤6/12 in either eye.[21]

Randomization, Interventions and Masking

The study was conducted as a cluster-randomized controlled trial, with randomization occurring at the township level. After receiving teacher-led vision screening from September to November 2014 (beginning of the school year), schools were randomly assigned by township (cluster size 5-6) to one of two groups: an Early Referral Group, in which all children failing screening were referred to the Vision Center for refraction and free glasses as needed from December 2014 to February 2015 (middle of the school year); and a Late Referral Group, which received the same intervention between March and June 2015 (end of the school year). Members of the study team conducted randomization at their offices at

Shaanxi Normal University, in Xi'an, China, using Stata 13.1 (StataCorp, College Station, TX).

In total, our study included 11 townships (clusters), with an observed inter-cluster coefficient (ICC) of 0.025. Assuming an alpha of 0.05 and a R^2 of 0.5, our study was powered to observe an effect size of 0.25 at 80% power.

Teachers initially received one day of instruction on vision screening by Vision Center staff. Parents of children with uncorrected visual acuity ≤6/12 in either eye received a letter describing the program and inviting them to bring their children to the Vision Center for a free examination including rescreening, refraction, and a free pair of glasses if needed. Teachers also provided a list of students failing screening to the Vision Center staff, who made follow-up phone calls to both schools and families to encourage parents to bring their children for services.

Participants (students, parents, and teachers) and Vision Center staff were not informed of the study design or group assignment. Because teachers did not have the skills to conduct vision screenings until receiving formal training, and the formal trainings were only administered by our research staff at the assigned time, contamination across treatment arms was nearly impossible. Participants were told only that this was a study of vision care among rural, school children. Teachers were unaware that they were participating in a trial and were masked to group assignment at the time of outcome assessment.

Data collection

In September 2014, all sampled students were administered a standardized mathematics test as an index of academic achievement. The test was administered by the

Bureau of Education and proctored by teachers in each school. Mathematics was chosen for testing to reduce the effect of home learning on performance. Immediately prior to the start of program interventions in each school, teachers administered a socioeconomic survey to all children, collecting information on gender, glasses ownership, boarding status, and parental migration and educational attainment. Finally, in June 2015, all sample students were again administered the standardized mathematics test and socioeconomic survey.

Our primary outcome was the endline mathematics score, adjusted for the baseline score, and expressed in standard deviations (SD). Secondary outcomes were self-reported glasses ownership and wear at the time of the endline survey. Children were asked to describe their glasses wear as "always," "only for studying," or "usually not worn."

School-based visual acuity assessment

Visual acuity was tested separately for each eye without refraction at 4 meters using Early Treatment Diabetic Retinopathy Study (ETDRS) charts (Precision Vision, La Salle, IL, USA) in a well-lighted, indoor area.[22] Children owning glasses were requested to bring them to school, and their visual acuity was tested with and without habitual correction. Visual acuity for an eye was defined as the lowest line on which 4 of 5 optotypes were read correctly. If the top line could not be read at 4 meters, the subject was tested at 1 meter, and the measured visual acuity was divided by 4.

Vision Center-based vision screening

All vision screening at Vision Centers was carried out by one of the three trained refractionists in the Yongshou County Hospital Vision Center, following China's strict "National Guidelines for Vision Care" for prescribing spectacles. Specifically, the refractionists followed six steps before prescribing spectacles to sample children. First, they discussed the child's corrective lens history and re-administered the visual acuity screening described above. Based on the results of this screening, children with uncorrected visual acuity ≤6/12 in either eye underwent cycloplegia with up to three drops of cyclopentolate 1%, preceded by a drop of proparacaine hydrochloride 0.5%, to prevent accommodation and inaccurate refraction. All center-based vision testing was conducted in a single visit for each child, including cycloplegia. Children then underwent automated refraction (Topcon KR 8900, Tokyo, Japan) with subjective refinement by the refractionist. Children were eligible for spectacle prescription if they had an uncorrected visual acuity of ≤6/12 in either eye after cycloplegia. Finally, before prescribing spectacles, the refractionist measured each child's interpupillary distance and measured the lens power of the child's original glasses (if any). The Vision Center was stocked with roughly 10 different styles of child-friendly frames. Children were allowed to choose whichever frames they liked best.

Statistical methods

All analyses were performed using Stata 13.1 (StataCorp, College Station, TX), calculating robust standard errors to adjust for clustering by township. Baseline and endline mathematics scores were standardized for each grade separately to give a mean of 0 and SD of 1 among Late Referral Group children at baseline. Baseline glasses ownership was defined as having a pair of glasses at school, after being asked to bring them. Refractive power was defined throughout as the spherical equivalent: spherical power plus half the cylindrical power.

For intention-to-treat analyses with glasses ownership and wear as outcomes, generalized linear models with Poisson regression were used to estimate the relative risk for the intervention arm, adjusting for baseline glasses ownership and other covariates.[23] One-way analysis of variance was used to estimate the intra-class correlation coefficient as a measure of clustering of endline math scores and glasses ownership and wear within each township. Randomization groups were compared by intention-to-treat using multiple linear regression, with endline math scores as the primary outcome for the main hypothesis, and treatment assignment and baseline math scores as covariates. For the secondary hypothesis regarding uptake of glasses, the secondary outcomes were self-reported glasses ownership and wear ("only for studying" or "always", compared to "mostly not worn").

Missing data

To reduce the inefficiency of estimation owing to missing values, we used multiple imputation in Stata as described by Royston to impute the following data at baseline: boarding at school (n=34),[24] both parents out-migrated for work (n=30), and one or both parents with ≥9 years education (n=51).[24] We used logistic regression for binary variables and ordered logistic regression for ordinal variables. The independent variables used for imputation included all non-missing variables (Table 1). For each variable, different models were used for selecting the independent variables based on predictive value and data availability. The multiple imputation approach created 20 copies of the data in which missing values were imputed by chained equations. Final results were obtained by averaging these 20 data sets using Rubin's rules, which ensured that the standard errors for all regression coefficients take into account the uncertainty in the imputations as well as uncertainty in the estimation.[24]

Results

A total of 20 schools (6 townships, 543 children) were randomized to the Early Referral group and 11 schools (5 townships, 657 children) to the Late Referral group (Figure 1). Of the 2,613 sample children screened at 31 selected schools in 11 townships, 1200 children (45.9%) failed their school-based vision screening, indicating an uncorrected visual acuity of ≤6/12 in either eye. The average visual acuity at baseline for sample students who met the study criteria for poor vision was 6/24 in the better eye.

Of the 1200 poor vision students identified during the school-based screening, 251 children (20.9%) were lost to follow-up due to a failure to complete the endline mathematics test. This left a final analytic sample of 949 students: 433 children in the Early Referral group and 516 children in the Late Referral group (Figure 1). Children in the two groups did not differ on any individual-level or cluster-level variables at baseline (Table 1).

At endline, unadjusted mathematics scores were higher in the Early Referral group (Table 2: 0.30SD, 95% CI 0.002 to 0.614; p = 0.05). This is consistent with results from the full multivariate model (Table 3: 0.25 SD, 95% CI 0.01 to 0.48); p=0.04). We find that baseline mathematics score and parental education are predictors of a higher endline math score (Table 3).

Our unadjusted results (Table 2) further show that rates of both glasses ownership and glasses wear were higher in the Early Referral group (ownership: 80.1% vs. 61.4%, difference = 18.7% [95% CI: 6.19% to 31.22%]; P = 0.008; wear: 75.3% vs. 55.4%, difference = 19.9% [95% CI: 2.62% to 37.10%]; P = 0.03). Again, these results are consistent with the results of the multivariate analysis, which show higher rates of glasses ownership and wear among children in the Early Referral group. Predictors of glasses ownership at endline in multivariate models included baseline ownership (RR = 1.32, 95% CI 1.08 to 1.60, $p = 0.005$) and uncorrected visual acuity (children with worse visual acuity were more likely to own glasses: RR = 1.76, 95% CI 1.49 to 2.08, $p < 0.001$). Results were very similar for glasses wear at endline, with baseline glasses ownership and worse uncorrected visual acuity the only associated variables (Table 4).

Discussion

Principal Findings

Intention-to-treat analysis in this trial found a statistically significant improvement in mathematics test scores among children randomized to receive early versus late referral to a Vision Center after vision screening, where they received free glasses if needed. The observed effect size of 0.25 SD is the equivalent of approximately half a semester of additional learning.[25]

Previous studies of programs providing free glasses[8,12,26] have generally shown low resulting ownership and wear, even when educational interventions to promote glasses use were included.[8, 27] The positive results of this trial have important implications for future glasses distribution programs: our results suggest that placement of a Vision Center in a local hospital can significantly increase service uptake and educational outcomes.

Comparison with other studies

We searched PubMed on April 11, 2014, using the terms "refractive error" and "myopia," cross-indexed with "glasses" and "spectacle," and "Vision Center", "vision care", "distribution", "impact", "educational", "academic" and "school performance" for articles published in any language since 1970. We found no previous randomized trials designed to examine the effect of local spectacle service-delivery models on children's school performance, ownership of glasses and glasses wearing behavior.

A recent review of randomized trials with educational outcomes in primary schools in the developing world listed 60 health related trials, including 22 deworming studies, with a mean effect size of 0.013 SD, and 38 nutritional studies, with a mean effect size of 0.035 SD. The impact on educational outcomes achieved through the provision of glasses in this study (0.25 SD) thus compares very favorably with that of other health related interventions.[28,29]

Strengths and limitations of the study

Strengths of this study include its randomized controlled design, population-based sampling, successful collaboration with the local Bureau of Education and the local county hospital in the conduct of the study, and a policy-relevant choice of county hospital as the distribution point for glasses, all of which increase confidence in the findings and their relevance to actual programs. Weaknesses must also be acknowledged: the unadjusted effect size of our main study outcome was of only borderline statistical significance, though the adjusted effect size was significant and the point estimate of 0.25-0.3 D was larger than recorded in a previous similar trial. Further, all schools were drawn from a single county in rural northwest China, which limits external validity. Other weaknesses include the fact that follow-up was only modest (79.1%), although the impact of this was reduced somewhat by the fact that children with and without follow-up differed only with regard to visual acuity (Table 1), and follow-up rates did not differ between groups. Also, one of our secondary outcome variables (spectacle wear) relied on self-report data, which may overestimate actual behavior.[8,19] For ethical reasons, our study design delivered an identical service to both the Early and Late Referral groups, which may be viewed as a weakness, but the fact that the Late group received refraction and glasses late in the school year meant that the expected impact on our principal outcome, performance on the mathematics test, would logically be reduced due to having a shorter period of learning without visual impairment. Finally, we did not attempt in the current paper to calculate program costs or attempt any economic modeling, which may be valuable in the future.

Despite these limitations, this study tests the county hospital-based model of refractive service delivery, and suggests this model may be an important one for China and other countries with a high prevalence of refractive error.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: the free frames used in this study were supplied by OneSight, Luxottica-China. The authors have no other financial relationships with any organizations that might have an interest in the submitted work in the previous three years, and no other relationships or activities that could appear to have influenced the submitted work.

Author contributions: YM, MB, YS and SR designed the study. YM and YS collected and analyzed the data. NC, SR, AM, and RH assisted in data interpretation. YM wrote the manuscript, and AM, NC, RH, SR, YS, and MB provided critical revisions. All authors were involved in the decision to submit the paper for publication, and approved of the final draft for submission. YM had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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[Figure 1: Enrollment and progress of children through the randomized trial.]

Table 1. Baseline characteristics of children with correctable refractive error, by group assignment

Variables	Analytic Sample † (n = 949)			Full Sample † (n = 1200)			Difference between full and attrited samples		
	Early Referral Group (n = 433)	Late Referral Group (n = 516)	P-value, Early Referral vs Late Referral Group	Early Referral Group (n = 543)	Late Referral Group (n = 657)	P-value, Early Referral vs Late Referral Group	Analytic Sample (n = 949)	Attrited Sample (n = 251)	P-value, Analytic Sample vs Attrited Sample
Male sex, n (%)	219 (50.6)	251 (48.6)	0.67	277 (51.0)	322 (49.0)	0.64	470 (49.5)	129 (51.4)	0.68
Math score, mean (SD)*	0.09 (1.1)	-0.05 (1.0)	0.59	0.04 (1.1)	-0.05 (0.9)	0.70	0.01 (1.0)	-0.09 (1.0)	0.33
Distance between town and county seat, km, mean (SD)*	24.2 (15.8)	27.4 (11.6)	0.75	23.7 (15.8)	28.2 (11.1)	0.63	25.9 (13.7)	27.1 (13.0)	0.73
Visual acuity of better eye, LogMAR, mean (SD)*	0.6 (0.2)	0.7 (0.3)	0.11	0.6 (0.2)	0.7 (0.3)	0.09	0.64 (0.28)	0.57 (0.23)	0.009
Owned glasses, n (%) ‡	120 (27.7)	153 (29.7)	0.72	140 (25.8)	195 (29.7)	0.42	273 (28.8)	62 (24.7)	0.32
Boarding at school, n (%)	42 (9.7)	81 (15.7)	0.57	61 (11.2)	95 (14.5)	0.74	123 (13.0)	33 (13.2)	0.98
One or both parents with >= 9 years of education n (%)	82 (18.9)	96 (18.6)	0.93	101 (18.6)	136 (20.7)	0.58	178 (18.7)	59 (23.5)	0.36
Both parents out-migrated for work, n (%)	54 (12.5)	88 (17.1)	0.35	73 (13.4)	110 (16.7)	0.41	142 (15.0)	41 (16.3)	0.71

* SD=standard deviation

‡ Defined as having glasses at school at baseline, having previously been told to bring them to school

† Analytic sample includes all sample children for whom we have both baseline and endline data. Full sample includes all sample children for whom we have only baseline data but no endline data.

Table 2: Math score, glasses ownership and wear by study group at endline visit (N = 949)

Outcome variables at endline visit	Early Referral Group (n = 433)	Late Referral Group (n = 516)	P-value, Early vs Late†
Math score, mean (SD)*	0.14 (1.01)	-0.16 (0.97)	0.05
Self-reported glasses ownership, n (%)	347 (80.1)	317 (61.4)	0.008
Self-reported glasses wear, n (%)	326 (75.3)	286 (55.4)	0.03

* SD=Standard deviation
† 2-sample t test

Table 3: Linear regression model of potential predictors of endline math score.

Characteristics	Univariate model adjusted for baseline math score (n=949)		Full model (n=949)	
	Regression coefficient‡ (95% CI) †	P-value	Regression coefficient (95% CI) †	P-value
Early Referral Group	0.22 (-0.05 to 0.50)	0.10	**0.25 (0.01 to 0.48)**	**0.04**
Male sex, n (%)	0.04 (-0.14 to 0.22)	0.60	0.02 (-0.16 to 0.21)	0.77
Baseline standardized mathematics score (SD)*	**0.53 (0.42 to 0.65)**	**<0.001**	**0.53 (0.42 to 0.63)**	**<0.001**
Distance between town and county seat, km (SD)*	0.00 (-0.01 to 0.02)	0.34	0.01 (0.00 to 0.02)	0.21
Visual acuity of better eye, LogMAR (SD)*	0.32 (-0.36 to 0.42)	0.86	0.10 (-0.37 to 0.57)	0.64
Owned glasses at baseline	-0.04 (-0.22 to 0.14)	0.60	-0.09 (-0.30 to 0.12)	0.36
Boarding at school at baseline	0.04 (-0.18 to 0.25)	0.70	0.06 (-0.26 to 0.38)	0.67
One or both parents with >= 9 years of education n (%)	**0.12 (0.01 to 0.23)**	**0.04**	**0.13 (0.01 to 0.26)**	**0.03**
Both parents out-migrated for work, n (%)	0.0001 (-0.21 to 0.21)	0.99	0.01 (-0.16 to 0.19)	0.87

‡ Except for the regression coefficient for baseline math score (simple regression), coefficients for the different variables are for multiple models with endline math score as dependent variable, adjusted for baseline math score

† 95% CI: 95% Confidence interval. Bold type indicates comparisons for which the 95% Confidence Interval for effect size does not cross zero.

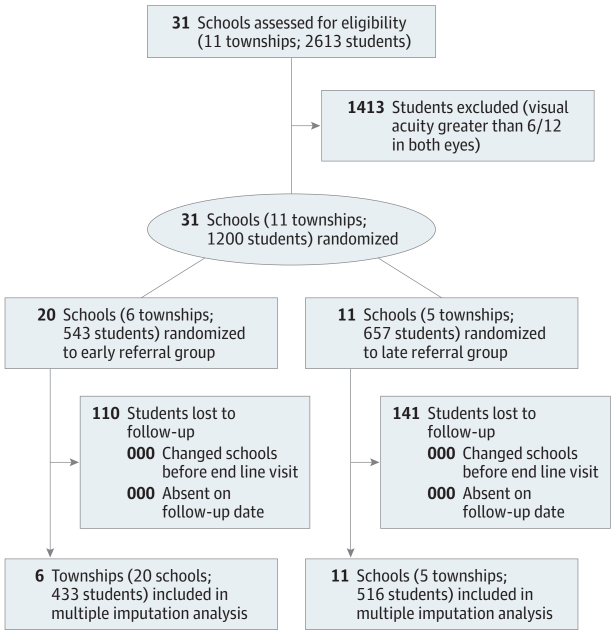
* SD: Standard deviation.

Table 4: Linear regression model of potential predictors of self-reported glasses ownership and wear.

Variables	Self-reported glasses ownership at endline				Self-reported glasses wear at endline			
	RR (95% CI)† Univariate adjusted for baseline ownership (n = 949)	P-value	RR (95% CI) full model † (n = 949)‡‡	P-value	RR (95% CI)† Univariate adjusted for baseline ownership (n = 949)	P-value	RR (95% CI)† full model (n = 949)	P-value
Early Referral Group	**1.32 (1.13 to 1.55)**	**0.001**	**1.36 (1.15 to 1.60)**	**<0.001**	**1.38 (1.07 to 1.78)**	**0.01**	**1.43 (1.10 to 1.86)**	**0.008**
Male sex, n (%)	0.96 (0.90 to 1.03)	0.31	0.96 (0.89 to 1.05)	0.34	0.98 (0.87 to 1.09)	0.70	0.97 (0.85 to 1.12)	0.70
Baseline standardized mathematics score (SD)*	1.02 (0.96 to 1.09)	0.47	1.00 (0.96 to 1.05)	0.99	1.02 (0.94 to 1.11)	0.60	0.99 (0.94 to 1.05)	0.82
Distance between town and county seat, km (SD)*	1.00 (0.99 to 1.00)	0.22	1.00 (0.99 to 1.00)	0.27	1.00 (0.99 to 1.00)	0.26	1.00 (0.99 to 1.00)	0.37
Visual acuity of better eye, LogMAR (SD)*	**1.61 (1.29 to 2.01)**	**<0.001**	**1.76 (1.49 to 2.08)**	**<0.001**	**1.51 (1.22 to 1.87)**	**<0.001**	**1.87 (1.59 to 2.22)**	**<0.001**
Owned glasses at baseline, n (%)	**1.56 (1.29 to 1.88)**	**<0.001**	**1.32 (1.08 to 1.60)**	**0.005**	**1.72 (1.35 to 2.20)**	**<0.001**	**1.43 (1.11 to 1.85)**	**0.005**
Boarding at school at baseline, n (%)	0.95 (0.81 to 1.11)	0.48	0.98 (0.86 to 1.11)	0.76	0.99 (0.84 to 1.17)	0.94	1.03 (0.89 to 1.20)	0.64
One or both parents with >= 9 years of education n (%)	1.03 (0.99 to 1.08)	0.15	1.03 (0.97 to 1.11)	0.29	0.99 (0.91 to 1.09)	0.90	1.00 (0.91 to 1.10)	0.96
Both parents out-migrated for work, n (%)	0.91 (0.81 to 1.04)	0.16	0.94 (0.84 to 1.06)	0.29	0.89 (0.78 to 1.01)	0.09	0.93 (0.82 to 1.05)	0.23

† 95% CI: 95% Confidence interval. Bold type indicates comparisons for which the 95% Confidence Interval for effect size does not cross zero.
* SD: Standard deviation.

Figure 1


31 Schools assessed for eligibility (11 townships; 2613 students)
1413 Students excluded (visual acuity greater than 6/12 in both eyes)
31 Schools (11 townships; 1200 students) randomized
20 Schools (6 townships; 543 students) randomized to early referral group
11 Schools (5 townships; 657 students) randomized to late referral group
110 Students lost to follow-up
000 Changed schools before end line visit
000 Absent on follow-up date
141 Students lost to follow-up
000 Changed schools before end line visit
000 Absent on follow-up date
6 Townships (20 schools; 433 students) included in multiple imputation analysis
11 Schools (5 townships; 516 students) included in multiple imputation analysis