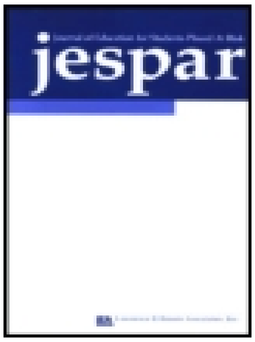

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In Plain Sight: Reading Outcomes of Providing Eyeglasses to Disadvantaged Children

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ABSTRACT
Many disadvantaged students with refractive errors, such as myopia (nearsightedness) and hyperopia (farsightedness), do not have eyeglasses, and their reduced vision may impact reading proficiency. Providing eyeglasses may increase their reading success. This article reports the findings of a study in Baltimore City in which disadvantaged second and third graders were assessed for vision problems. Of 317 students, 182 were given glasses. Those who needed glasses were given two pairs, one for home and one for school, as well as replacements if glasses were lost or broken. School staff assisted in ensuring that students wore their glasses, storing them safely, and replacing glasses when necessary. Students who received glasses improved more on Woodcock reading measures than those who never needed glasses ($ES = +0.16$, $p < .03$). The study demonstrates the potential of providing eyeglasses to disadvantaged students who need them to improve their reading performance.

The most important problem in reading education is the persistent gap in reading performance between students in disadvantaged schools and those in non-disadvantaged schools.The National Assessment of Educational Progress (NCES, 2015) reported that 21% of students qualifying for free- or reduced-price lunch scored at or above "proficient," in comparison to 52% of students who did not qualify for free lunch. Among African-Americans, 18% scored at or above "proficient," and among Hispanics, 21% did so, in comparison to 46% of Whites. These differences are well known to education researchers and policy makers, and have driven research and policy for many years. Research and policy have focused on curricula, teaching methods, accountability, and other changes within the education system (e.g., Allington, 2011; Gambrell, Morrow & Pressley, 2007; National Reading Panel, 2000;

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Schwanenflugel & Knapp, 2015; Temple, Ogle, Crawford, & Freppon, 2016). Progress in reducing achievement gaps has been painfully slow, with gaps narrowing only marginally since 1980.

One element in this disparity may have been hiding in plain sight: vision. Disadvantaged and minority schoolaged children are far less likely than middle class and White children to obtain and wear eyeglasses if they need them (Ganz, Xuan, & Hunter, 2007; Heslin et al., 2006; National Center for Children's Vision and Eye Health, 2016; Qiu, Wang, Singh, & Lin, 2014; Zhang et al., 2012). A New York City study, for example, found that 28% of disadvantaged middle school students needed glasses, but only 7% had them (Bodack, Chung, & Krumholtz, 2010). Uncorrected vision problems are known to lead to diminished learning through childhood (Basch, 2011; Creavin et al., 2015; Granet, 2011; Kiely, Crewther, & Crewther, 2001; Levine, 1984; Maples, 2003) and even into adulthood (Davidon & Quinn, 2011).

While some educational policy experts (e.g., Duncan & Murnane, 2014; Rothstein, 2004) have proposed that interventions to address health issues such as vision might help to close achievement gaps, a clear demonstration of the benefit of these interventions for academic achievement has not been made. We report on a school-based program to examine and then distribute glasses to second and third grade students in disadvantaged schools and present the impact of this intervention on reading.

Why disadvantaged students lack eyeglasses

The reasons that disadvantaged early school-age children who need glasses do not have them are complex. First, although most states provide vision screening at various intervals, the period of time between mandated screenings may be long. In Maryland, for example, children are only screened in pre-kindergarten or kindergarten, first grade, and eighth grade (or first entry into a district). Second, some disadvantaged children are missed in state or district screening programs (Ganz et al., 2007). Typically, if a child fails an initial screening, his or her parents are sent a note recommending a complete vision assessment by an eye care provider. Many parents do not follow through, usually because they cannot afford an eye exam or eyeglasses or because they do not know how to access free tests and glasses or those covered by insurance (Kimel, 2006).

If parents do persist and obtain glasses for their child, the next hurdle is maintenance. Children frequently break or lose their glasses. Replacement is time-consuming and may be expensive. A disadvantaged parent may not have time to take their child for a second exam or second visit to an optical shop, while retaining a job and surviving economically. Glasses can be expensive, especially if there is no insurance coverage. Many disadvantaged children will have Medicaid, but such funding varies by state. In Maryland, Medicaid typically covers the cost of one replacement pair of eyeglasses each year, although in some states there is no public funding of glasses, or there is only limited coverage.

A logical alternative to the traditional method of accessing eye care could be a school-based program. The staff at the child's school care for the child five days a week, and are likely to be known and be trusted by the child's parents. Further, the school is held accountable for the academic achievement of all children, and therefore school staff have a stake in each child's vision. In principle, the school, in partnership with parents, is a logical institution to ensure that children have and use needed eyeglasses. Yet school staff do not have the resources or the authority to deal with vision problems, so if parents are unable to follow through, school staff may watch helplessly as capable children fail due to correctable vision problems.

A study in a single high-poverty California elementary school by Kodjebacheva, Maliski, Yu, Oelrich, and Coleman (2014) provided first and second graders with eye evaluations, and two pairs of glasses if they needed them. Teachers monitored the use of eyeglasses, and parents received eye care education. The proportion of children wearing eyeglasses in class increased from 7% to 73% over six months.

Previous attempts to solve the problem

The fact that large numbers of disadvantaged students have untreated vision problems could have a simple solution: Assess children and provide glasses in the school setting. In fact, there are large charities, such as ChildSight (part of the Helen Keller Foundation) and Vision To Learn (http://visiontolearn.org/), a Los Angeles charity, that do just this for disadvantaged children in the cities where they are active. Cities and states vary in how much emphasis they place on vision in schoolage children. While this work seems obviously beneficial to children, evidence supporting the effects of these efforts on school success is lacking, and therefore sufficient resources are rarely allocated to providing glasses to those who need them.

This is not merely a problem of documenting the obvious. Even if one accepts the idea that eyeglasses benefit reading, the problems cited above explain why assessment and eyeglass distribution may be necessary but not sufficient to solve the vision problem for a disadvantaged school district. Even in concerted citywide screening efforts some children are missed, or their parents do not follow through with a recommendation to get glasses, or lost or broken glasses are not replaced (Ganz et al., 2007). Solving the eyeglasses problem in disadvantaged schools is not a one-time intervention (assessment followed by glasses), but instead an ongoing effort to ensure that vision problems are solved and stay solved. For this to work, school staff members must be engaged and empowered to keep track of vision issues, and parents and students themselves must be engaged in support of the idea that vision care is an essential part of learning.

The approach in this research follows the philosophy of Atul Gawande (2007), the Harvard surgeon who writes about the importance of ensuring that solutions to health problems produce the intended outcomes. His stories of success in this regard usually involve empowering front-line providers to ensure that medical treatments are properly implemented, so that the intended beneficiaries benefit from the time, energy, and resources expended on their behalf. In the case of vision, the effectiveness of eyeglasses for reading has been known for hundreds of years. But in order to ensure that provision of eyeglasses solves the problem, what may be needed are replicable, efficient systems administered in partnership with vision care professionals by front-line staff closest to the children: teachers and school leadership.

In order to understand how eyeglasses work, a few basic explanations are in order. Eyeglasses are primarily prescribed for people who have poor vision due to refractive error, which is the degree to which a person's eyes have difficulty seeing things up close (hyperopia, or farsightedness) or far away (myopia, or nearsightedness). A third factor is astigmatism, an abnormality in the shape of the eyes that defocuses vision. Refractive error is measured on a scale called diopters, where "normal vision" or emmetropia is indicated by a score near zero. Positive values indicate hyperopia, and negative values indicate myopia.

There is limited research on the achievement impacts of interventions designed to provide eyeglasses to children who need them, and it is not clear that all types of refractive errors are the same. The largest study to assess learning outcomes after provision of eyeglasses to students who needed them took place in Gansu Province, in rural Northwest China. In one study (Hannum & Zhang, 2012), children in grades 3–5 had their vision tested and those who did not already wear glasses were randomly assigned to receive free glasses or to remain in a control group. Results indicated a positive treatment effect ($ES = +0.34$, $p < .002$) for literacy, and a positive effect for math ($ES = +0.26$, $p < .014$), but no significant difference for language. In a similar one-year study, also in Gansu Province, Glewwe, Park, and Zhao (2011) randomly assigned 1,528 students in grades 4–6 with vision problems to be offered glasses or not. Controlling for pretests, effect sizes were +0.17 for Chinese, +0.17 for math, and +0.13 for science. A third study in the same province (Ma et al., 2014) randomly assigned 84 schools either to receive free glasses for students who needed them, or to a control group. About 33% of students needed glasses. Only the effect on math achievement was significant, averaging $ES = +0.11$, $p < .05$.

The study presented here is the first school-based U. S. study to assess the effect of providing eyeglasses on the reading performance of disadvantaged students who need them.

Methods

Participants

This total initial sample included 317 second- and third- graders in 12 disadvantaged Baltimore City schools. These were all of the second and third graders in these schools whose parents submitted signed informed consent forms. All schools were using the Success for All reading program (Slavin, Madden, Chambers, & Haxby, 2009). 84.5% of students were African-American, 8.5% were Hispanic, and 4.4% were White. All students qualified for free lunch.

Procedures

Students' vision was tested in the fall and winter of 2014–15. Individual reading pretests were administered around the same time. Students were given reading posttests in the spring of 2015. An average of 3.73 months ($SD = 1.69$) elapsed between reading pretests and posttests.

Students given eyeglasses were compared in terms of reading posttest measures to students who did not need glasses, controlling for reading pretests. This comparison group was necessary because it would have been unethical to test students' vision and then fail to give eyeglasses to all who needed them. Instead, students who did not meet study criteria for eyeglasses served as a counterfactual to indicate how much gain would have taken place over the same period of time without any eyeglass treatment. Students with vision problems other than refractive error, such as strabismus, nystagmus, and convergence insufficiency ($n = 55$), were dropped from the experiment, as they neither had normal vision nor needed glasses. This left a sample size of 262, composed of students who needed glasses ($n = 182$) and students without vision problems ($n = 80$).

Instrumentation

Vision assessments

Students' vision was assessed by a pediatric ophthalmologist or a pediatric optometrist from the Wilmer Eye Institute at the Johns Hopkins School of Medicine. Specific procedures for testing have been described elsewhere (Collins et al., 2015). Children were individually brought from their classroom to a room in the school and underwent a complete vision assessment. This included near and distance visual acuity, stereoacuity, extraocular motility, strabismus evaluation, a dilated fundoscopic exam, and cycloplegic refraction.

In order to determine if even low refractive errors impact reading performance, the study used a liberal threshold for prescribing glasses, one that identified more children as needing glasses than would be typical in clinical practice. Children were prescribed eyeglasses if they had refractive errors of -0.50 diopters or greater (indicating myopia) or +1.00 diopters or more (indicating hyperopia).

Children were also assessed for near point of convergence, meaning the ability to use their eyes together, and accommodative ability, meaning the ability to focus on things that are close up. This testing was performed to determine if children had convergence insufficiency (difficulty converging eyes for near activity) or accommodative insufficiency (difficulty focusing for near activity). As noted earlier, unless these students also had refractive error and needed glasses, they and other children with vision problems other than refractive error were excluded from the study.

All children who met study criteria for eyeglasses were given two pairs of glasses, one for home and one for school. Children diagnosed with convergence insufficiency were instructed on performing twice daily orthoptic vergence exercises (i.e., focusing on a near target as they brought it toward their nose). Their parents and teachers were also instructed on how each child should perform the eye exercises.

The teachers of children who received glasses were given storage boxes for the classroom to store school eyeglasses. The glasses themselves as well as hard-shell eyeglass cases were labeled with each child's name. The eyeglass cases also were labelled with instructions about when to wear eyeglasses, e.g. full-time, or during class and homework. Teachers were regularly reminded to have students wear their glasses. Further, Wilmer staff visited schools approximately once a month to replace lost or broken glasses, and to adjust ill-fitting glasses.

Reading assessments

Reading measures were the Letter-Word Identification and Word Attack scales from the Woodcock Language Proficiency Battery, individually administered at pre- and posttest by trained testers from the Johns Hopkins University School of Education. The results from Letter-Word Identification and Word Attack were averaged to form a total reading score.

Data analysis

In order to allow for combining of reading scores across second and third graders, scores were transformed to z-scores. Scores from students with normal vision were set at a mean of zero and a standard deviation of 1.00, and then scores of students who received eyeglasses were expressed on the same scale. Posttest reading scores for all students who received eyeglasses were compared to those of students who did not need glasses, controlling for pretests, using analyses of covariance (ANCOVA).

Results

At baseline vision testing, 69% of students in the analytic sample were found to need eyeglasses, according to the study-specified refractive criteria. 81 (31%) had myopia, 101 (39%) hyperopia, and 80 (31%) did not need glasses. 64 (34%) also had astigmatism, but all of these students also had myopia or hyperopia, so these students are only included in the myopia and hyperopia subsamples. A small number of children required further evaluation by a pediatric eye care provider in a medical setting. Table 1 summarizes the baseline vision data.

Children were asked if they could recall having a prior eye exam, and 147 (56%) said they had. Children were asked if they had ever worn glasses, and 105 (40%) said that they had. However, at baseline vision assessment, only 6.3% of children had their glasses. We found a substantial unmet need for glasses; if self-reports by these young children were correct, large numbers had been evaluated in the past and had been given glasses, but few still had them.

Pretest differences on reading and language

Baseline differences were compared between students given glasses and those with normal uncorrected vision on reading measures (Table 1). Although students with refractive errors tended to score less well in reading than students with normal vision, none of these differences was statistically significant. This makes students with normal vision an acceptable comparison group to those children who received eyeglasses.

Longitudinal outcomes

Longitudinal outcomes on reading were determined from the sum of Woodcock Letter-Word and Word Attack scales. The outcome analyses compared reading scores for children in each category of refractive error, who were given eyeglasses, to students with normal vision, who were not. Post-test

Table 1. Pretest differences on reading measures used as covariates in all analyses*.

	N	Reading (*SD*)
Full Sample		
Given Eyeglasses	182	−0.03 (1.15)
Normal Vision	80	0.00 (0.99)
Myopia/Hyperopia		
Myopia	81	0.14 (1.14)
Hyperopia	101	−0.12 (1.16)
Normal Vision	80	0.00 (0.99)
Mild/Moderate/Severe		
Mild	104	0.00 (1.07)
Moderate/Severe	78	−0.07 (1.24)
Normal Vision	80	0.00 (0.99)

**Note*: Reading scores are the average of Woodcock Letter-Word Identification and Word Attack scales. Scores of students with normal vision were transformed to a mean of 0.00 and a standard deviation of 1.00 to allow for combining across grades. Scores of students given glasses were put on this same scale. None of the differences at pretest between students given glasses and those with normal vision were statistically significant.

Table 2. Reading Gains for All Students Given Eyeglasses In Comparison to Students with Normal Vision*.

	Reading Scores					
	N	Pre Mean (*SD*)	Post Mean (*SD*)	Adj. Mean	Effect Size	
Given Eyeglasses	182	−0.03 (1.07)	0.14 (1.02)	0.15	+0.16	p<.02
Normal Vision	80	0.00 (0.93)	0.00 (0.99)	−0.01		

**Note:* Reading scores are the average of Woodcock Letter-Word Identification and Word Attack scales. Students with normal vision are the comparison group. Scores of the students with normal vision were transformed to a mean of 0.00 and a standard deviation of 1.00 to allow for combining across grades. Scores of students given glasses were put on this same scale. Posttests are adjusted for pretest reading scores.

differences were controlled for pretest reading scores. Pre- and post-test reading data were obtained from all 262 students who otherwise qualified for the study. Table 2 shows the findings.

Among all students who were prescribed and given eyeglasses, reading performance improved significantly more than for those students who did not need glasses. On combined reading scores, the effect size comparing students who were given glasses and those who did not need them was +0.16 ($p < .02$).

Table 3 shows the outcomes broken down for students whose refractive error was diagnosed as myopia (nearsightedness), and Table 4 shows outcomes for those whose refractive error was diagnosed as hyperopia (farsightedness), in comparison with students with normal vision. The effect of receiving eyeglasses was statistically significantly positive for children with myopia ($ES = +0.19$, $p < .03$), but only marginally significant for children with hyperopia ($ES = +0.13$, $p < .10$).

It would be logical to expect that students with larger refractive errors would benefit more from receiving eyeglasses than would students with milder problems. Students given glasses were divided into two categories by dividing at the median for myopia and hyperopia: Mild ($n = 104$) or moderate to severe ($n = 78$) (Table 5). The reading effect sizes for students with moderate to severe refractive errors ($ES = +0.18$, $p < .05$) and for students with mild refractive error ($ES = +0.17$, $p < .05$), were nearly identical.

Limitations

It is important to note several limitations of this study. First, the key comparison was between the reading gains of students who received eyeglasses based on assessed needs and those of students who did not need glasses. Ideally, the comparison would be between students who needed glasses who were randomized to receive or not receive them. For this study that randomization was not possible as it would not be considered ethically acceptable to not provide glasses for students identified as needing them. Second, the sample sizes were too small for sufficient analytic power for subgroups based on type of refractive error. It is easy to understand how myopia could affect school performance for distance work, but it is less clear how it would affect reading performance. Third, the treatment was administered at the school level. In a much larger study, schools could have been randomly assigned to provision of glasses in a cluster randomized design, and data could have been analyzed at the school level.

Table 3. Reading Gains for Students Diagnosed With Myopia In Comparison to Students with Normal Vision*.

	Reading Scores					
	N	Pre Mean (*SD*)	Post Mean (*SD*)	Adj. Mean	Effect Size	
Myopia	81	0.01 (1.14)	0.21 (1.03)	0.20	+0.19	$p < .03$
Normal Vision	80	0.00 (0.99)	0.00 (0.99)	−0.01		

**Note*: Reading scores are the average of Woodcock Letter-Word Identification and Word Attack scales. Students with normal vision are the comparison group. Scores of students with normal vision were transformed to a mean of 0.00 and a standard deviation of 1.00 to allow for combining across grades. Scores of students given glasses were put on this same scale. Posttests are adjusted for pretest early reading scores.

Table 4. Reading Gains for Students Diagnosed with Hyperopia In Comparison to Students with Normal Vision*.

	Reading Scores					
	N	Pre Mean (*SD*)	Post Mean (*SD*)	Adj. Mean	Effect Size	
Hyperopia	101	−0.12	0.03 (1.00)	0.08	+0.13	$p<.10$
Normal Vision	80	0.00 (0.93)	0.00 (0.99)	−0.05		

**Note*: Reading scores are the average of Woodcock Letter-Word Identification and Word Attack scales. Students with normal vision are the comparison group. Scores of students with normal vision were transformed to a mean of 0.00 and a standard deviation of 1.00 to allow for combining across grades. Scores of students given glasses were put on this same scale. Posttests are adjusted for pretest early reading scores.

This would have provided better control for other factors that may have effected reading scores. Fourth, the treatment took place over a period of less than an academic year. A longer intervention period could increase the impact. Alternatively, if part or all of the impact were due to a Hawthorne or novelty effect of getting new glasses, a longer study duration might reduce the impact. Finally, qualitative data or participant-reported outcomes would be useful to better understand how the vision services affected schools, teachers, and students.

Discussion

We found substantial unmet needs for vision services in disadvantaged schools in Baltimore City, a problem that likely exists in other similar locations. For a variety of reasons, students who need eyeglasses in these schools typically do not have them. Providing eyeglasses and support intended to increase use of eyeglasses and replace those that are lost or broken was found to increase reading performance significantly, with an effect size of +0.16 ($p < .02$). Effects were greater for students with myopia ($ES = +0.18$, $p < .03$) than for those with hyperopia ($ES = +0.13$, $p < .10$).

The benefits of receiving eyeglasses were not restricted to students with severe vision problems. Beneficial effects were seen for children with lesser levels of both myopia and hyperopia, though the effect was only statistically significant for children with myopia.

The small sample size of this study makes our conclusions tentative. If replicated on a larger scale, these data suggest one way poverty may lead to negative impacts on student reading achievement. If it is the case that large numbers of students in high-poverty schools benefit from eyeglasses, then the lack of glasses may be a factor in their low achievement. Students in these challenging environments whose vision is reduced may conclude that they are simply not good at reading. Reading may give them eyestrain or headaches, it may be effortful rather than pleasurable, and students may not know why they struggle to read.

Teachers and parents may not be surprised if a disadvantaged child fails to read well, and may not investigate to find out whether vision problems could be involved in a child's reading difficulties. In contrast, parents with more financial resources and time may be more likely to make certain their

Table 5. Reading Gains for Students with Mild and Moderate/Severe Refractive Error, In Comparison to Students with Normal Vision*.

	Reading Scores					
	N	Pre Mean (*SD*)	Post Mean (*SD*)	Adj. Mean	Effect Size	
Mild Problems	104	0.01 (1.07)	+0.16 (1.02)	0.15	+0.18	$p<.05$
Moderate/Severe Problems	78	−0.10 (1.12)	0.12 (1.03)	0.15	+0.17	$p<.05$
Normal Vision	80	0.00 (0.93)	0.00 (0.99)	−0.02		

**Note*: Reading scores are the average of Woodcock Letter-Word Identification and Word Attack scales. Students with normal vision are the comparison group. Scores of students with normal vision were transformed to a mean of 0.00 and a standard deviation of 1.00 to allow for combining across grades. Scores of students given glasses were put on this same scale. Posttests are adjusted for pretest early reading scores.

Determination of "mild" vs. "moderate/severe" refractive error was made based on median splits within the distribution of children with myopia and those with hyperopia.

children's vision has been tested, provide them with glasses if necessary, and encourage their use. They are more likely to see poor reading performance or reading-related somatic complaints as atypical, and to persist until they find solutions.

The problem of vision in high-poverty schools is not a simple matter of putting eyeglasses on children. Based on data from a later citywide study, about 30% of students in Baltimore failed a vision screening and, of these, 80% qualified for eyeglasses based on standard criteria. In this study. 40% of students in the study sample claimed they had been given glasses in the past. However, only 6% still had them with them in school, suggesting that the great majority of children who needed glasses never received them, or if they did, lost or broke them by second or third grade. Many students could not have their vision tested because their parents never sent in permission forms. Despite exceptional efforts by the research staff, only about half of parents sent in forms, even though the glasses were free. In order to increase submission of parent permission forms, and use and maintenance of glasses, schools and parents need to be engaged as partners with vision professionals to ensure that all students who need glasses are identified, given glasses, and then encouraged to use them, keep them safe, and replace them when necessary.

The findings of the present study replicate findings of similar studies that took place in China (Glewwe et al., 2011; Hannum & Zhang, 2012; Ma et al., 2014), and like them, it shows that providing eyeglasses to students who need them could improve academic achievement. However, there is much additional research needed to further inform this topic. First, studies in the United States are needed to test the effects of eyeglass provision with random assignment at the school level. This would enable researchers to compare students who were offered glasses to those who were not, as in the Ma et al. (2014) study in China. This would provide a more suitable control group than the convenience sample in the current study. Second, research is needed on the effects of time. It may be that students who receive eyeglasses show immediate benefit in their academic performance, or on the contrary, it may be that students need to use their glasses for some time before benefits appear. Also, due to students losing or breaking glasses or failing to wear them every day, impacts of glasses may fade over time unless timely and conscientious efforts are made to promptly replace broken and lost glasses.

Other research might focus on the minimum requirements for determining which students need glasses. The present study used liberal prescribing criteria, and students with mild refractive errors seemed to benefit. But this was a surprising finding worth replicating.

A key factor in maximizing vision services to children who needed glasses was the difficulty of obtaining consent in high-poverty schools. Very few parents denied consent, but many failed to send in forms after many reminders. Finding ways to improve consent rates, or using passive consent (opt out), may help solve this problem. Finally, outcomes of vision service interventions may be different for students of different ages, socio-economic status, urban/rural locations, and ethnicities, and these moderators are important to understand.

The study reported here is the first U. S. school-based investigation of its kind, to our knowledge, linking provision of eyeglasses to enhanced reading performance, and it is important in suggesting an important new avenue for improving reading success in high-poverty schools, but additional research is needed to validate and better understand these findings.

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