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ORIGINAL ARTICLE

Teachers' influence on purchase and wear of children's glasses in rural China: The PRICE study

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Importance: Uncorrected refractive error causes 90% of poor vision among Chinese children.

Background: Little is known about teachers' influence on children's glasses wear.

Design: Cohort study.

Participants: Children at 138 randomly selected primary schools in Guangdong and Yunnan provinces, China, with uncorrected visual acuity (VA) ≤6/12 in either eye correctable to >6/12 in both eyes, and their teachers.

Methods: Teachers and children underwent VA testing and completed questionnaires about spectacles use and attitudes towards children's vision.

Main Outcome Measures: Children's acceptance of free glasses, spectacle purchase and wear.

Results: A total of 882 children (mean age 10.6 years, 45.5% boys) and 276 teachers (mean age 37.9 years, 67.8% female) participated. Among teachers, 20.4% (56/275) believed glasses worsened children's vision, 68.4% (188/275) felt eye exercises prevented myopia, 55.0% (151/275) thought children with modest myopia should not wear glasses and 93.1% (256/275) encouraged children to obtain glasses.

Teacher factors associated with children's glasses-related behaviour included believing glasses harm children's vision (decreased purchase, univariate model: relative risk [RR] 0.65, 95% CI 0.43, 0.98, $P < 0.05$); supporting children's classroom glasses wear (increased glasses wear, univariate model: RR 2.20, 95% CI 1.23, 3.95, $P < 0.01$); and advising children to obtain glasses (increased free glasses acceptance, multivariate model: RR 2.74, 95% CI 1.29, 5.84, $P < 0.01$; increased wear, univariate model: RR 2.93, 95% CI 1.45, 5.90, $P < 0.01$), but not teacher's ownership/wear of glasses.

Conclusions and Relevance: Though teachers had limited knowledge about children's vision, they influenced children's glasses acceptance.

KEYWORDS

children, China, glasses, myopia, rural, teacher

1 | INTRODUCTION

There were 13 million children in the world visually impaired (visual acuity [VA] <6/18) from under-corrected refractive error (URE) in 2004, and among them almost half live in China.[1] URE accounts for >90% of visual disability among rural Chinese children.[2,3] Glasses correction is a safe[4] and effective means for treatment of URE, and has been demonstrated to improve children's educational outcomes,[5] but only 15% to 20% of Chinese rural[5] and urban migrant[6] children who need glasses have them.

Many reasons exist for this situation. Refractionists practicing in rural China are minimally trained,[7] and together with existing optical dispensing services, frequently deliver spectacles whose power is not accurate.[8] A number of stakeholders, including children, families and teachers, believe incorrectly that wearing glasses will lead to faster progression of myopia in children,[9,10] despite randomized trial evidence that this is not the case.[4]

It has been shown that rural Chinese teachers can accurately perform vision screening for children with only modest training,[11] and incentivizing teachers can significantly improve urban migrant children's rates of classroom spectacle wear.[12] Given the potentially important role of teachers in children's spectacle delivery programs, further study of their influence on the purchase and wear of children's glasses is needed in the more typical setting where formal teacher incentives are not used.

We carried out a cluster-randomized, controlled trial in rural Guangdong and Yunnan Provinces, China, to evaluate the impact of giving free glasses on the purchase and wear of children's spectacles. During data collection, the head teachers of 276 classes were interviewed about their own spectacle wear, and attitudes and knowledge about children's glasses and vision. The objective of the current paper is to assess the impact of various teacher factors on acceptance of free glasses, purchase of glasses and children's in-school wear of glasses during the trial.

2 | METHODS

The protocol for this study has been described elsewhere in detail[13] and was approved in full by Institutional Review Boards at Stanford University (Palo Alto, California), the Zhongshan Ophthalmic Center (Guangzhou, China) and Yunnan Red Cross Hospital (Kunming, China). Permission was received from local Boards of Education in each setting, and the principals of all schools and at least one parent provided written informed consent for the participation of each child. The principles of the Declaration of Helsinki were followed throughout.

2.1 | Setting, sampling and eligibility criteria

The study was carried out in Guangdong and Yunnan Provinces, China. Guangdong ranked ninth among China's 31 administrative divisions in per capita Gross Domestic Product in 2014 (US$ 10 330), while Yunnan was 29th (US $4438).[14] Nine counties or county-level cities were selected, five from Yunnan and four from Guangdong, all having a county-level hospital capable of providing refractive services and willing to participate in the study.

A detailed list of 601 elementary schools in these counties (362 in Guangdong and 239 in Yunnan) was provided by local bureaus of education, including information on the number of classes in each school and the number of students per class. Schools with average class sizes <20 or > 60 students (19% of the sample frame) were excluded, because screening at larger schools could not reliably be completed in a day, which would have interfered with the screening schedule, and smaller schools would be expected to have <7 children requiring glasses, the minimum number required in our power calculations. From the list of 601 schools, 107 schools (57 in Guangdong and 50 in Yunnan) were randomly selected, with the number of schools selected in each county proportional to population size. An additional 31 schools were randomly selected as above to achieve adequate power for the parent trial, after initial vision screening revealed a lower-than-expected prevalence of refractive error. Thus, a total of 138 schools (88 in Guangdong and 50 in Yunnan) were enrolled. Within each sampled school, one class in each of the fourth and fifth grades (likely age range 9-12 years) were randomly selected, if there was more than one class per grade level. All head teachers of the selected classes were offered the opportunity to take part in the study.

All children in the selected classes meeting both the following criteria were considered eligible for the study:

- Uncorrected (without glasses) VA of ≤6/12 in either eye correctable to >6/12 in each eyes with glasses (ie, correctable refractive error);
- Refractive error as follows: myopia ≤ −0.75 diopters (D), hyperopia ≥ 2.00 D, or astigmatism (non-spherical refractive error) ≥ 1.00 D.[15]

2.2 | Questionnaires

At baseline (September 2014, beginning of the school year), enumerators administered questionnaires to children, including questions on race (Han vs various minority groups), age, sex, glasses wear, awareness of refractive status, belief that wearing glasses harms children's vision, parental living condition and education and ownership of a list of 16 selected items as an index of family wealth. At endline (June 2015, end of the school year), student questionnaires were administered on glasses ownership, glasses wear, parental attitude towards

wearing glasses and subjective evaluation of project glasses. Information collected on teachers included presenting VA, glasses ownership, and various questions concerning teachers' attitudes and knowledge about children's vision, wear of glasses and management of myopia. These were graded on a 5-point Likert scale, from "Strongly agree" to "Strongly disagree."

2.3 | VA assessment

Children and teachers underwent VA screening at school by two trained volunteers. VA was tested separately for each eye with spectacles (if available) and without spectacle correction at 4 m using Early Treatment Diabetic Retinopathy Study charts[15] (Precision Vision, La Salle, Illinois) in a well-lighted, indoor area. If the subject correctly identified the orientation of at least four of five optotypes on the 6/60 line, s/he was examined on the 6/30 line, then the 6/15 line and then line by line to 6/3. VA in an eye was defined as the lowest line on which four of five optotypes were read correctly. If the top line could not be read at 4 m, the participant was tested at 1 m and the measured VA was divided by four.

2.4 | Refraction

Children with uncorrected VA ≤6/12 in either eye underwent cycloplegia with up to three drops of cyclopentolate 1% in each eye after anaesthesia with topical proparacaine hydrochloride 0·5%. Children then underwent automated refraction (Topcon KR 8900, Tokyo, Japan) with subjective refinement by an experienced refractionist. Children of parents refusing permission for cycloplegia (274/882 = 31.1%) underwent subjective refinement of the non-cycopleged value from the auto-refractor by an experienced refractionist in each eye using a target at four meters distance. Head teachers with presenting VA ≤6/12 in either eye were offered non-cycloplegic refraction following the above protocol, and were provided with free glasses if needed.

2.5 | Randomization and outcome assessment in the parent trial

In October 2014, after the baseline survey and vision screening but before refraction, eligible children were randomized by school to four groups. The Control group received only a prescription for glasses and a note to the parents suggesting spectacles be purchased. The remaining three groups received either free glasses alone or free glasses with the additional offer of "Upgrade glasses" (having scratchproof lenses and more popular designs based on previous research on the preferences of rural Chinese children) at two different prices. Records at the participating county hospitals were used to determine families' acceptance of free glasses and purchase of upgrade glasses (where provided). Children's self-report on questionnaires at the endline examination provided data on purchase of spectacles outside of the study. At this time, spectacle wear was assessed through unannounced direct examinations.

2.6 | Definitions

"Acceptance" of glasses was defined as having gone to the distribution facility to receive free glasses, in the Intervention group. "Purchase" of glasses was buying any glasses in the Control group, and purchase of upgrade glasses in the Intervention group. "Wear" of glasses indicates presence of the glasses on the child's face under conditions of direct observation, in either study group.

2.7 | Statistical methods

Baseline characteristics of teachers and students were presented as mean (SD, SD) for continuous data with normal distribution, median (IQR, Inter Quartile Range) for continuous data with non-normal distribution and frequency (percentage) for categorical data. Baseline wear of glasses was defined as having glasses at school, having been told to bring them. We calculated family wealth by summing the value, as reported in the China Rural Household Survey Yearbook (Department of Rural Surveys, National Bureau of Statistics of China, 2013), of items on the list of 16 owned by the family. Refractive power was defined throughout as the spherical equivalent: the spherical power plus half the cylindrical power. Teachers' knowledge, practices and attitudes about students' myopia and glasses wear were presented as frequencies (percentage). A teacher's knowledge score was defined as the sum of five knowledge items, coded on a Likert scale from 1 ("Strongly agree" with a true statement or "Strongly disagree" with a false one) to 5 ("Strongly disagree" with a true statement or "Strongly agree" with a false one). Thus, the possible range was 5 (Best) to 25 (Worst).

Generalized linear models with Poisson regression were used to estimate the relative risk for acceptance of free spectacles, purchase and wear of glasses. All children attending the endline examination were included in the regression analysis for purchase and wear of glasses, while Control group children, who were not offered free glasses, were excluded from the analysis on acceptance of free spectacles. All variables significant at the $P \leq 0.2$ level in the simple regression models were included in the multiple regression model. Regression analyses were performed separately for all children and for children undergoing cycloplegic refraction (608/882 = 68.9%). Statistical analysis was done using a commercially available software package (Stata 13.1, StataCorp, College Station Texas).

3 | RESULTS

A total of 276 teachers (mean age 37.9 [8.51] years, 67.8% female) participated in this study, among whom 145 (52.7%) reported owning glasses, and 44 (19.1%) had presenting VA in the better-seeing eye ≤6/12. Among teachers with uncorrected VA ≤ 6/12 in either eye, 91.5% (86/94) had distance glasses, and 54.1% (46/86) of these indicated they routinely wore them (Table 1).

TABLE 1 Characteristics of teachers participating in a study of purchase and wear of children's glasses in rural China ($N = 276$)

Teacher characteristic	Result	Missing value; n (%)
Age (years: Mean [SD])	37.9 (8.51)	3 (1.09)
Female sex (n, %)	187 (67.8)	0 (0.00)
Yunnan residence (n, %)	100 (36.2)	0 (0.00)
Teaching experience (years: n, %)		2 (0.72)
1-10	81 (29.6)	
11-20	95 (34.7)	
≥21	98 (35.8)	
Presenting VA (better-seeing eye[a]) (n, %)		45 (16.3)
≤6/12	44 (19.1)	
>6/12	187 (80.9)	
Self-reported glasses ownership (n, %)		1 (0.36)
Yes	145 (52.7)	
No	130 (47.3)	
Self-reported distance glasses wear among those with uncorrected VA in either eye ≤ 6/12 (n = 86) (n, %)		1 (1.16)
Rarely worn	12 (14.1)	
Worn when studying or working	27 (31.8)	
Routinely worn	46 (54.1)	
Self-reported distance glasses wear among those with presenting VA in better-seeing eye ≤ 6/12 (n = 28) (n, %)		1 (3.57)
Rarely worn	8 (29.6)	
Worn when studying or working	13 (48.2)	
Routinely worn	6 (22.2)	

Abbreviation: SD, standard deviation; VA, visual acuity.
[a] The eye with better uncorrected VA for those without glasses or better corrected VA for those with glasses.

After screening 10 234 children, a total of 882 children with correctable refractive error (mean aged 10.6 [0.95] years, 45.5% male) at 138 schools met enrolment criteria and took part, among whom only 104 (11.8%) were wearing glasses at baseline. Among all children, 311 (35.3%) had uncorrected visual acuity <6/18 in the better-seeing eye, and 220 (25.0%) believed that wearing glasses harms the vision. Other baseline characteristics of children and their families are summarized in Table 2.

Among teachers, 20.4% (56/275) believed wearing glasses would worsen children's vision, 68.4% (188/275) felt traditional Chinese eye exercises could prevent myopia and 55.0% (151/275) thought that children with modest degrees of myopia should not wear glasses. (Table 3) The majority of teachers (140/275 = 50.9%) thought that glasses could not treat myopia or were uncertain, while only a very small minority (3/275 = 1.09%) believed that excessive studying was a cause of myopia among children in their class. Majorities of teachers supported children wearing glasses in their classrooms (242/273 = 88.6%) and reported actively reminding children in their classes to obtain glasses during the project (256/275 = 93.1%). (Table 3).

TABLE 2 Baseline characteristics of 882 children with correctable refractive error[a] participating in a study of purchase and wear of glasses in rural China. (number, %, unless otherwise indicated)

Characteristics	Results
Age (years, mean [SD])	10.6 (0.95)
Male sex	401 (45.5)
Wearing glasses at baseline[b]	104 (11.8)
Yunnan residence	183 (20.8)
Spherical equivalent refractive error (diopters)	
≤−2.00	323 (36.6)
>−2 to −0.5 (−2, 0.5]	479 (54.3)
>−0.5 to 0.5 (−0.5, 0.5]	60 (6.80)
>0.5	20 (2.27)
Uncorrected VA < 6/18 in eye with better vision	311 (35.3)
Only child in family	126 (14.3)
One or both parents with ≥ 12 y of education	272 (30.8)
Both parents out-migrated for work	154 (17.5)
At least one parent wears glasses	172 (19.5)
Self-reported study time each day after school	
<0.5 h	341 (38.7)
0.5-1 h	293 (33.2)
>1 h	248 (28.1)
Percentage of classroom teaching done on blackboard (as opposed to books at students' desks)?[c]	
All	97 (11.0)
More than half	376 (42.7)
Half	224 (25.5)
Rarely	161 (18.3)
None	22 (2.50)
Family wealth, median (inter quartile range), USD[c,d]	
Bottom tercile (n = 283, 32.2%)	2202 (1624-2464)
Middle tercile (n = 301, 34.3%)	3746 (3246-4183)
Top tercile (n = 294, 33.5%)	14 170 (12 387-14 952)
Study group (number of children [%])	
Control	257 (29.1)
Free glasses	253 (28.7)
Free glasses + $e15 upgrade	187 (21.2)
Free glasses + $e30 upgrade	185 (21.0)

[a] Uncorrected (without glasses) VA of ≤6/12 in either eye correctable to >6/12 in each eye with glasses.
[b] Defined as having glasses at school at baseline, having previously been told to bring them to school.
[c] Two missing values.
[d] Four missing values.
[e] 1USD = 6.5RMB.

Families of 269/625 (43.0%) of children accepted the offer of free glasses in the study (257 children in the Control group were not eligible to receive them), while families of 169/882 (19.2%) of children had purchased glasses (either those offered as "upgrades" by the study, or outside the study) by the time of the endline examination. At this unannounced endline examination, 205/867 (23.6%) of children were observed wearing spectacles (15/882 = 1.7% of children had been lost to follow-up.)

TABLE 3 Teachers' knowledge (correct answers in parentheses), practices and attitudes about children's myopia and glasses wear ($N = 276$)

Variables	n (%)
Eye exercises prevent myopia [a] (treated as false for purposes of analysis)	
Very much agree	49 (17.8)
Agree	139 (50.55)
Neither agree nor disagree	68 (24.7)
Disagree	19 (6.91)
Very much disagree	0 (0.00)
Having myopia but not wearing glasses will negatively affect learning [a] (true)	
Very much agree	82 (29.8)
Agree	148 (53.8)
Neither agree nor disagree	31 (11.3)
Disagree	13 (4.73)
Very much disagree	1 (0.36)
Wearing glasses will worsen children's vision [a] (false)	
Very much agree	10 (3.64)
Agree	46 (16.7)
Neither agree nor disagree	88 (32.0)
Disagree	124 (45.1)
Very much disagree	7 (2.55)
There is no need for children with modest degrees of myopia to wear glasses[a] (false)	
Very much agree	26 (9.45)
Agree	125 (45.5)
Neither agree nor disagree	56 (20.4)
Disagree	65 (23.6)
Very much disagree	3 (1.09)
Myopia can be successfully treated with glasses[a] (true)	
Very much agree	17 (6.18)
Agree	118 (42.9)
Neither agree nor disagree	82 (29.8)
Disagree	56 (20.4)
Very much disagree	2 (0.73)
Teacher's knowledge score (points)[a,b], mean (SD)	15.5 (2.23)
Attitude towards students in my class wearing glasses[c]	
Support	242 (88.6)
Not support	31 (11.4)
Best way to manage a child's myopia problem? (choose one only)[a]	
Wear glasses	182 (66.2)
Use eye drops	2 (0.73)
Perform eye exercises	62 (22.6)
Eat a nutritious diet	11 (4.00)
Use other medicines	2 (0.73)
Do surgery	4 (1.45)
Other way	12 (4.36)
Main reason for myopia among children in your class? (choose one only)[a]	
Excessive study time	3 (1.09)
Watching television	159 (57.8)
Using other electronic devices (computers, games)	63 (22.9)
Insufficient light while reading	32 (11.6)
Genetic factors	11 (4.00)
Other reasons	7 (2.55)
Did you advise your students to obtain glasses?[a]	
Yes	256 (93.1)
No	19 (6.91)

[a] One missing value.
[b] The total teacher's knowledge score was sum score of five knowledge items with five-level Likert scales, true statement items were reverse coded to make 1 [worst]-5 [best]. The possible range was 5-25.
[c] Three missing values.

Table 4 shows teacher and child/family factors associated with acceptance, purchase and wear of children's glasses. Teacher factors associated with acceptance and wear of glasses in either univariate or multivariate models included: believing wearing glasses harms children's vision (decreased purchase of glasses in the univariate model only: Relative Risk [RR] 0.65, 95% CI 0.43, 0.98, $P < 0.05$); supporting students wearing glasses in class (increased glasses wear in the univariate model only: RR 2.20, 95% CI 1.23, 3.95, $P < 0.01$) and advising children to obtain glasses (increased acceptance of free glasses in the univariate model RR 3.50, 95% CI 1.43, 8.61, $P < 0.01$, and in multivariate model RR 2.74, 95% CI 1.29, 5.84, $P < 0.01$); increased glasses wear in the univariate model only: RR 2.93, 95% CI 1.45, 5.90, $P < 0.01$), but not teacher's ownership or wear of or knowledge about glasses (Table 4). Additionally, having a teacher older than the median age of 37 significantly decreased children's observed wear of glasses: univariate model RR 0.68, 95% CI 0.51, 0.90, $P < 0.01$, multivariate model RR 0.74, 95% CI 0.57, 0.96, $P < 0.05$; having a female teacher reduced acceptance of free glasses in the univariate model: RR 0.73, 95% CI 0.55, 0.95, $P < 0.05$, while increasing purchase of glasses: univariate model RR 1.73, 95% CI 1.08, 2.75, $P < 0.05$, multivariate model RR 2.20, 95% CI 1.41, 3.43, $P < 0.001$.

Child/family factors associated with spectacle acceptance in multivariate models included Yunnan residence, where children were more likely both to accept free glasses (RR 1.42, 95% CI 1.09, 1.85, $P < 0.05$) and to purchase them (RR 1.75, 95% CI 1.22, 2.51, $P < 0.01$). Additionally, children with better uncorrected vision (univariate model RR 0.07, 95% CI 0.03, 0.16, $P < 0.001$, multiple model RR 0.28, 95% CI 0.11, 0.68, $P < 0.01$) were more likely not to be wearing glasses, and those wearing glasses at baseline (RR 2.68, 95% CI 2.03, 3.54, $P < 0.001$) were more likely to be wearing glasses at endline. Being in the top tercile of family wealth (RR 1.45, 95% CI 1.08, 1.95, $P < 0.05$) and studying >1 h/d (RR 1.37, 95% CI 1.01, 1.86, $P < 0.05$) were associated with greater likelihood of wearing glasses at endline, though only in the univariate model (Table 4).

TABLE 4 Effect of potential student and teacher factors on acceptance, purchase prior to endline and wear of glasses at endline adjusting for cluster effect within school ($N = 882$)

	Acceptance of free spectacles [a,b]		Purchase of spectacles [b]		Endline glasses wear [b]	
	Simple regression	Multiple regression	Simple regression	Multiple regression	Simple regression	Multiple regression
Variable	**RR (95% CI)[c]**	**RR (95% CI)[d]**	**RR (95% CI)[c]**	**RR (95% CI)[d]**	**RR (95% CI)[c]**	**RR (95% CI)[d]**
Teacher factors						
Teacher's age above median (37) (below median as reference)	0.76 (0.58, 1.00)	0.87 (0.69, 1.10)	1.11 (0.79, 1.55)		**0.68 (0.51, 0.90)****	**0.74 (0.57, 0.96)***
Female teacher	**0.73 (0.55, 0.95)***	0.85 (0.67, 1.08)	**1.73 (1.08, 2.75)***	**2.20 (1.41, 3.43)*****	1.17 (0.80, 1.72)	
Teacher's presenting visual acuity ≤ 6/12 (better-seeing eye)	0.94 (0.62, 1.42)		1.28 (0.81, 2.00)		0.80 (0.48, 1.32)	
Teacher owns glasses	1.04 (0.79, 1.37)		1.10 (0.77, 1.56)		0.97 (0.70, 1.34)	
Teacher wears glasses routinely in class	0.79 (0.57, 1.09)	0.87 (0.62, 1.21)	0.86 (0.58, 1.29)		0.81 (0.54, 1.20)	
Teacher believes wearing glasses harms children's vision (disagree as reference)						
Agree	0.78 (0.53, 1.14)	0.78 (0.56, 1.09)	**0.65 (0.43, 0.98)***	0.99 (0.59, 1.65)	0.94 (0.59, 1.49)	
Indifferent	0.80 (0.60, 1.06)	0.87 (0.69, 1.09)	1.09 (0.75, 1.60)	1.48 (0.99, 2.22)	1.07 (0.72, 1.60)	
Teacher's attitude towards students wearing glasses in class						
Supports	1.70 (0.86, 3.34)	1.41 (0.90, 2.22)	1.62 (0.88, 2.95)	1.54 (0.84, 2.84)	**2.20 (1.23, 3.95)****	1.36 (0.72, 2.55)
Not support	Reference	Reference	Reference	Reference	Reference	Reference
Teacher advised children to purchase glasses (never advised as reference)	**3.50 (1.43, 8.61)****	**2.74 (1.29, 5.84)****	1.42 (0.77, 2.60)		**2.93 (1.45, 5.90)****	2.34 (0.99, 5.56)
Teacher's knowledge score (points)	1.05 (0.97, 1.13)		1.07 (0.99, 1.15)	1.06 (0.97, 1.17)	1.07 (0.99, 1.15)	1.03 (0.95, 1.12)
Student factors						
Age (years)	0.99 (0.89, 1.10)		0.91 (0.79, 1.06)		0.89 (0.79, 1.01)	0.90 (0.78 1.04)
Male sex	0.89 (0.74, 1.06)	0.93 (0.79, 1.10)	0.82 (0.62, 1.07)	0.81 (0.62, 1.06)	0.92 (0.71, 1.20)	
Wearing glasses at baseline [e]	1.00 (0.71, 1.40)		**0.58 (0.35, 0.98)***	0.63 (0.38, 1.04)	**4.66 (3.69, 5.88)*****	**2.68 (2.03, 3.54)*****
Yunnan residence (vs Guangdong)	**1.77 (1.36, 2.32)*****	**1.42 (1.09, 1.85)***	**1.63 (1.07, 2.49)***	**1.75 (1.22, 2.51)****	1.17 (0.75, 1.83)	
Spherical equivalent refractive error (diopters), (>−0.5 to 0.5 as reference)						
≤−2.00	1.11 (0.74, 1.66)		1.45 (0.77, 2.73)		**3.11 (1.50, 6.45)****	1.11 (0.54, 2.29)
>−2 to −0.5 (−2, 0.5]	1.25 (0.85, 1.83)		1.22 (0.62, 2.41)		1.31 (0.63, 2.70)	0.95 (0.48, 1.89)
>0.5	1.13 (0.54, 2.37)		0.33 (0.04, 2.54)		**3.37 (1.38, 8.26)****	1.66 (0.77, 3.57)
Uncorrected VA in eye with better vision (decimal)	1.01 (0.68, 1.49)		0.72 (0.40, 1.30)		**0.07 (0.03, 0.16)*****	**0.28 (0.11, 0.68)****
Only child in family (vs > 1 child)	1.13 (0.88, 1.46)		1.01 (0.69, 1.47)		1.29 (0.96, 1.74)	0.84 (0.65, 1.09)
One or both parents with ≥ 12 y of education (vs < 12 year)	0.88 (0.70, 1.11)		1.19 (0.86, 1.65)		**1.33 (1.05, 1.70)***	1.12 (0.90, 1.40)
Both parents away from the home the majority of time (vs lived at home)	0.81 (0.60, 1.08)	0.84 (0.65, 1.10)	1.02 (0.73, 1.44)		**0.65 (0.44, 0.96)***	0.72 (0.49, 1.05)
At least one parent wears glasses	0.93 (0.74, 1.17)		1.02 (0.74, 1.41)		**1.69 (1.32, 2.17)*****	1.17 (0.92, 1.50)
Self-reported study time each day after school (<0.5 h as reference)						
0.5–1 h	1.00 (0.80, 1.24)	0.99 (0.81, 1.20)	0.92 (0.68, 1.24)		1.13 (0.84, 1.52)	1.03 (0.79, 1.33)
>1 h	**0.70 (0.54, 0.92)****	**0.74 (0.58, 0.95)***	1.26 (0.86, 1.86)		**1.37 (1.01, 1.86)***	1.13 (0.84, 1.52)
Classroom teaching on the blackboard (less than half as reference)						
Half of teaching	1.02 (0.75, 1.38)		1.00 (0.66, 1.51)		1.17 (0.83, 1.64)	
More than half	1.11 (0.79, 1.57)		1.09 (0.67, 1.76)		1.22 (0.83, 1.79)	

TABLE 4 (Continued)

Variable	Acceptance of free spectacles [a,b]		Purchase of spectacles [b]		Endline glasses wear [b]	
	Simple regression RR (95% CI)[c]	Multiple regression RR (95% CI)[d]	Simple regression RR (95% CI)[c]	Multiple regression RR (95% CI)[d]	Simple regression RR (95% CI)[c]	Multiple regression RR (95% CI)[d]
Family wealth (bottom tercile as reference)						
Middle tercile	0.80 (0.62,1.03)	0.98 (0.79, 1.22)	1.15 (0.83, 1.60)		1.38 (0.98, 1.95)	1.04 (0.77, 1.39)
Top tercile	**0.74 (0.59, 0.92)****	0.82 (0.67, 1.02)	1.20 (0.85, 1.70)		**1.45 (1.08, 1.95)***	1.06 (0.79, 1.41)
Study group						
Control	Not included		Reference	Reference	Reference	Reference
Free glasses as reference	Reference		**0.54 (0.34, 0.85)****	**0.56 (0.36, 0.86)****	1.59 (0.98, 2.58)	1.41 (0.93, 2.15)
Free glasses + $15 upgrade	1.06 (0.76, 1.49)		0.90 (0.56, 1.45)	1.14 (0.75, 1.73)	1.17 (0.70, 1.97)	1.16 (0.76, 1.77)
Free glasses +$30 upgrade	0.85 (0.53, 1.34)		0.88 (0.53, 1.46)	0.86 (0.56, 1.31)	0.88 (0.46, 1.67)	0.95 (0.54, 1.65)

Significance is indicated by $*P < 0.05$, $**P < 0.01$, $***P < 0.001$. The data are adjusted for group assignment in the parent trial.

[a] Among students accepting free and free+ upgrade glasses from study at endline.

[b] 15 students who were lost to follow-up did not have outcome data.

[c] Only one predictor was included in the model.

[d] Variables with $P \leq 0.2$ were included in multiple regression model. 32/625 (5.12%) students for acceptance of free spectacles, 24/882 (2.72%) for purchase of spectacles and 37/882 (4.20%) for endline glasses wear were excluded in the multiple regression analysis due to missing values.

[e] Defined as having glasses at school at baseline, having previously been told to bring them to school.

4 | DISCUSSION

The current study highlighted a number of gaps in teachers' knowledge about children's vision and glasses wear. Majorities of teachers believed that glasses wear should be avoided or was harmful to children's vision, though recent evidence from randomized trials[4] suggests that this is not true, and that eye exercises prevent myopia, though little reliable evidence[16] exists in support of this. Nonetheless, a very large proportion of teachers reported both supporting and directly recommending that children obtain glasses, and these views and actions were significantly associated with glasses acceptance and wear by children.

Our own randomized trials[12] and reports from others[17,18] have suggested that interventions relying wholly or in part on teachers can be effective in increasing spectacle wear among children. Little information, however, exists on the impact of teacher knowledge and attitudes towards glasses wear on student wear of spectacles in the more typical situation where teachers are not actively being asked to promote wear, as in the current study. Other studies have attempted to elucidate teacher and parent attitudes towards children's wear of glasses in China[9] and elsewhere,[19,20] though without examining the impact of these attitudes on actual wear. Our finding in the current study that the recommendation of teachers significantly influenced acceptance of free glasses, even when adjusting for child/family factors, suggests that teachers play an important role in determining the behaviour of children and families in this setting, even outside of teacher incentive programs.

Though over half of teachers reported owning glasses, among teachers who owned distance glasses, only half of indicated that they wore them regularly, and one in five teachers had presenting VA ≤6/12 in either eye. These are consistent with findings from urban Indonesia,[21] where an even larger proportion of teachers had either uncorrected distance refractive error (36%) or uncorrected presbyopia (41%). In the current setting, neither teacher's ownership nor wear of glasses was significantly associated with any of the variables concerning children's acceptance of spectacles. Despite the lack of a direct effect on children's wear, the high proportion of teachers with poor VA reported in China and Indonesia[21] suggests that studies of the impact of VA on teaching effectiveness may be warranted in these settings, particularly in view of trial evidence that correction of children's refractive error significantly improves their educational outcomes.[5]

Significant, though not always consistent, associations were seen between age and gender on the one hand and children's acceptance of glasses on the other. Older teachers were less effective in promoting glasses acceptance, while female teachers had higher rates of spectacle purchase and lower rates of acceptance of free glasses in their classes. The implications for glasses promotion programs may be less

significant than our findings on the importance of teachers' attitudes, in that the latter are subject to change through interventions, while age and gender are not.

We found it unexpected that children who studied more were less willing to accept free glasses, and would have supposed that the opposite might be true. We expect this indicates that families of such children preferred to purchase upgrade glasses, rather than accepting free ones, which is consistent with our findings. We did not, however, find that the tendency of children who studied more being less likely to accept free glasses could be explained by a greater likelihood of glasses ownership at baseline (data not shown.)

Strengths of the current study include the large numbers of schools enrolled, and their selection at random in both rich and poor provinces of China, where lack of wear of glasses is a major public health problem; the relatively rich data on teachers' knowledge and attitudes; and the high rates of follow-up among children (98.3%) and carefully measured endpoints on their acceptance and wear of glasses. Limitations must also be acknowledged: we relied on teachers to report whether or not they encouraged children to obtain glasses. Further, only eight counties were enrolled in two provinces, and thus application of these results to other areas must be made with caution.

Nonetheless, this is among the few studies of the impact of teachers' knowledge, attitudes and behaviours on children's wear of glasses in China or elsewhere. It adds to a growing body of literature clarifying the role of teachers' promotion of spectacle acceptance.[12]

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CONFLICTS OF INTEREST

The free glasses used in this study were supplied by OneSight, Luxottica-China, and Essilor-China, producers of frames and lenses in China. The authors have no other financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; and no other relationships or activities that could appear to have influenced the submitted work.

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REFERENCES

1. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ*. 2008;86:63-70.
2. He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in southern China. *Invest Ophthalmol Vis Sci*. 2004;45:793-799.
3. He M, Huang W, Zheng Y, Huang L, Ellwein LB. Refractive error and visual impairment in school children in rural southern China. *Ophthalmology*. 2007;114:374-382.
4. Ma X, Congdon N, Yi H, et al. Safety of spectacles for Children's vision: a cluster-randomized controlled trial. *Am J Ophthalmol*. 2015;160:897-904.
5. Ma X, Zhou Z, Yi H, et al. Effect of providing free glasses on children's educational outcomes in China: cluster randomized controlled trial. *BMJ*. 2014;349:g5740.
6. Wang X, Yi H, Lu L, et al. Population prevalence of need for spectacles and spectacle ownership among urban migrant children in eastern China. *JAMA Ophthalmol*. 2015;133:1399-1406.
7. Zhou Z, Zeng J, Ma X, et al. Accuracy of rural refractionists in western China. *Invest Ophthalmol Vis Sci*. 2014;55:154-161.
8. Zhang M, Lv H, Gao Y, et al. Visual morbidity due to inaccurate spectacles among school children in rural China: the see well to learn well project, report 1. *Invest Ophthalmol Vis Sci*. 2009;50:2011-2017.
9. Li L, Lam J, Lu Y, et al. Attitudes of students, parents, and teachers toward glasses use in rural China. *Arch Ophthalmol*. 2010;128:759-765.
10. Li L, Song Y, Liu X, et al. Spectacle acceptance among secondary school students in rural China: the Xichang pediatric refractive error study (X-PRES)--report 5. *Invest Ophthalmol Vis Sci*. 2008;49:2895-2902.
11. Sharma A, Li L, Song Y, et al. Strategies to improve the accuracy of vision measurement by teachers in rural Chinese secondary schoolchildren Xichang pediatric refractive error study (X-PRES) report no 6. *Arch Ophthalmol*. 2008;128:1434-1440.
12. Yi H, Zhang H, Ma X, et al. Impact of free glasses and a teacher incentive on children's use of eyeglasses: a cluster-randomized controlled trial. *Am J Ophthalmol*. 2015;160:889-896. e1.
13. Wang X, Congdon N, Ma Y, et al. Cluster-randomized controlled trial of the effects of free glasses on purchase of children's glasses in China: the PRICE (potentiating rural Investment in Children's Eyecare) study. *PLoS One*. 2017;12:e0187808.
14. List of Chinese administrative divisions by GDP per capita. https://en.wikipedia.org/wiki/List_of_Chinese_administrative_divisions_by_GDP_per_capita. Accessed March 2016.
15. Congdon NG, Patel N, Esteso P, et al. The association between refractive cutoffs for spectacle provision and visual improvement among school-aged children in South Africa. *Br J Ophthalmol*. 2008;92:13-18.
16. Lin Z, Vasudevan B, Jhanji V, et al. Eye exercises of acupoints: their impact on refractive error and visual symptoms in Chinese urban children. *BMC Complement Altern Med*. 2013;13:306.
17. Ethan D, Basch CE, Platt R, Bogen E, Zybert P. Implementing and evaluating a school-based program to improve childhood vision. *J Sch Health*. 2010;80:340-345. quiz 368-70.
18. Kodjebacheva G, Maliski S, Yu F, Oelrich F, Coleman AL. Decreasing uncorrected refractive error in the classroom through a multifactorial pilot intervention. *J Sch Nurs*. 2014;30:24-30.
19. Kodjebacheva GD, Maliski S, Coleman AL. Use of eyeglasses among children in elementary school: perceptions, behaviors, and interventions discussed by parents, school nurses, and teachers during focus groups. *Am J Health Promot*. 2015;29:324-331.
20. Dudovitz RN, Izadpanah N, Chung PJ, Slusser W. Parent, teacher, and student perspectives on how corrective lenses improve child wellbeing and school function. *Matern Child Health J*. 2016;20:974-983.
21. Ehrlich JR, Laoh A, Kourgialis N, et al. Uncorrected refractive error and presbyopia among junior high school teachers in Jakarta, Indonesia. *Ophthalmic Epidemiol*. 2013;20:369-374.

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