The ROYAL COLLEGE of OPHTHALMOLOGISTS

www.nature.com/eye

ARTICLE

Check for updates

Translating and evaluating the Chinese version of Pediatric Eye Questionnaire (PedEyeQ-CN) for children

Ling Gong[1], Xi Yu[1], Lili Wei[1], Ran Zhang[1], Suqi Cao[1], Yue Xiong[1], Zhifen He[1], Meiping Xu[1], Huanyun Yu[1], Xinping Yu[2]✉, Fan Lu[1], Jia Qu[1] and Jiawei Zhou[1]✉

© The Author(s), under exclusive licence to The Royal College of Ophthalmologists 2022

OBJECTIVES: To investigate the reliability and validity of Chinese version of the Pediatric Eye Questionnaire (PedEyeQ-CN) by testing ophthalmic patients in China.

METHODS: The PedEyeQ (standard English version) was translated by local researchers. Children were asked to complete the Child section, and their parents the Proxy and Parent sections. 160 children (32 normal controls, 77 with refractive error, 48 with strabismus/amblyopia, 3 with other eye conditions) aged 5-11 years old, and one parent of each child were recruited. Cronbach's α and intraclass correlation coefficient were calculated to examine the reliability and test-retest reliability; the score differences between controls and patients were compared to examine the validity.

RESULTS: The internal consistency (Cronbach's $\alpha \geq 0.76$) and test-retest reliability ($r > 0.80$) of PedEyeQ-CN were robust. Children with eye conditions had lower scores compared with children with normal vision (refractive error: 10 out of 13 domains, $P \leq 0.021$; strabismus/amblyopia: all domains, $P \leq 0.015$). Children with strabismus/amblyopia had lower scores compared with children with refractive error (two domains, $P = 0.048$, $P = 0.001$). Visual acuity was significantly correlated with functional vision ($P = 0.005$), but not significantly correlated with the eye-related quality of life (ER-QOL).

CONCLUSIONS: The PedEyeQ-CN is a valuable tool for assessing the functional vision and ER-QOL of Chinese children and help us increase our understanding about the impact of eye conditions on children and their families.

Eye (2023) 37:1397–1404; https://doi.org/10.1038/s41433-022-02157-5

INTRODUCTION

The success or failure of medical therapy for eye diseases has often been estimated by the measurement of visual acuity using a standard test [1]. However, visual acuity is merely one of many visual functions and it is not representative of the patient's visual health. In short, an impairment of visual acuity does not fully capture the impact of poor vision on daily life for both children with visual impairment and their parents. A review indicates that ophthalmologists have underestimated the effect of eye disease on patients' quality of life because clinical examinations do not evaluate patient and their family's perception of the disease [2]. Recently, ophthalmologists and researchers have become more attentive to eye-related quality of life (ER-QOL). Eye-related deficits have been shown to affect children's social interactions and self-perception. For example, motor deficits (e.g., fine motor skill and eye–hand coordination deficits) in amblyopia [3–7] are associated with lower self-esteem, reduced social participation, and withdrawal from childhood social activities [8, 9]. Thus, a vision- and age-specific questionnaire is needed to understand how eye/vision affects children and their parents' ER-QOL.

The Pediatric Eye Questionnaire (PedEyeQ) has been developed to enable age-appropriate assessment of the impact of children's eye conditions on functional vision and ER-QOL from the child's and parents' perspectives [10]. Full questionnaires, with Rasch scoring lookup tables, are freely available at: https://public.jaeb.org/pedig/view/Other_Forms. Unlike pediatric questionnaires that have been designed for general quality of life, such as the Pediatric Quality of Life Inventory™ (PedsQL™) [11, 12], PedEyeQ evaluates the impact of disease-unspecific eye-related disorders. Therefore, it is applicable across various eye conditions [10]. Previous studies have found reduced functional vision and ER-QOL by PedEyeQ (i.e., lower scores in many domains) in children with bilateral visual impairment [13], strabismus [14, 15], amblyopia [14, 16], glasses wear [17], and other eye conditions [18]. Moreover, the PedEyeQ has been useful in clinical research, and it is believed that it can be helpful for clinical management [14]. However, there is a lack of availability of an equivalent tool to measure ER-QOL for non-English speaking populations, such as the children in China. To date, only the English and Spanish versions are available and cohorts in previous studies are mostly based in the United States and are anglophone [18]. Therefore, whether the results from these studies are generalizable across continents and languages is unknown.

Vision problems are common in China [19]. Also, the prevalence of different eye diseases in China is different from those of other countries. For example, the prevalence of myopia is higher in China with comparison with that in English-speaking countries (adolescents aged 7–18: 59.35% in China [20] vs. 20–40% in many

[1]School of Ophthalmology and Optometry, Eye Hospital, State Key Laboratory of Ophthalmology, Optometry and Vision Science, Wenzhou Medical University, Wenzhou, Zhejiang, China. [2]Zhongshan Ophthalmic Center, Sun Yat-Sun University, Guangzhou, Guangdong, China. ✉email: yu-xinping@163.com; zhoujw@mail.eye.ac.cn

Received: 25 February 2022 Revised: 8 June 2022 Accepted: 16 June 2022
Published online: 27 June 2022

western countries [21]). Myopia, ocular diseases associated with myopia (including glaucoma and retinal detachment), other common ocular diseases (for example strabismus and amblyopia), and the treatment of ocular diseases have been shown to have negative effects on health-related quality of life (HRQOL) [22–24] and ER-QOL [25, 26]. Thus, the investigation of ER-QOL of Chinese children is needed.

The original version of PedEyeQ is designed for three different age groups (0–4, 5–11, and 12–17 years old). In the present study, we translated PedEyeQ (5-11 years old) and collected data from children aged 5-11 years old. We evaluated whether the Chinese version (i.e., PedEyeQ-CN) could be useful in assessing children's functional vision and ER-QOL, and their parents' ER-QOL; both normal controls and ophthalmic patients (e.g., refractive error, strabismus, amblyopia, or other eye diseases) were tested.

SUBJECTS AND METHODS

Translation and cultural adaptation of PedEyeQ-CN (5-11 years old)

In this study, we translated PedEyeQ to get the Chinese version (PedEyeQ-CN) in six steps according to the process of translation and adaptation of instruments guidelines by the World Health Organization [27].

1. Translation of the PedEyeQ from English to Chinese by two translators,
2. Reconciliation of the two separate translations and then the process of drafting the second version of PedEyeQ-CN,
3. A reverse translation of the drafted PedEyeQ-CN back into English,
4. A comparison between the reverse-translated PedEyeQ and the original PedEyeQ, and subsequent revision of the PedEyeQ-CN to remove discrepancies between the two versions,
5. A test using the drafted PedEyeQ-CN on five adult participants to find unclear or confusing items,
6. Minor revision of the PedEyeQ-CN.

The second Chinese version (step 2) was developed by choosing the simpler words in the two translations (step 1). The aim of reverse translation (step 3) was the preservation of conceptual rather than literal meaning. The comparison of the reverse-translated version and the original version (step 4) was for confirming the meaning of each item had been maintained. All discrepancies were resolved through discussion by a panel of ophthalmologists and researchers. The cognitive debriefing (step 5) was conducted in five specialists in this area, including ophthalmologists in optometry department and amblyopia/strabismus department, and researchers in visual science. They had experience of outpatient service for children, and/or research experience with children. Two of them had questionnaire development experience. Also, they were parents of children aged 5–11 years old with or without eye conditions. The final version of PedEyeQ-CN was developed by further simplifying to reduce the difficulty of understanding (step 6). For example, Chinese idioms were all replaced by simple terms, long sentences were separated by comma, and key words were marked by quotes.

Participants

In total, 160 Chinese-speaking children, aged 5–11 years old, and 160 adults (one parent for each child), were recruited from the Eye Hospital of Wenzhou Medical University between July 2020 and January 2021. Children aged 5-11 years old were recruited because this age range is an important period for the development of children. Wang et al. [28], reported that the prevalence rate of myopia in Chinese children increases along with age in a non-linear fashion. For instance, the rate of myopia is around 11.6% for children aged 5–7 years old but rises to 69% in 11 years old. This appears to be the consequence of the typical period for the onset of myopia (the primary school stage from 6 to 11 years) in Chinese children [20, 29].

Children with no refractive error, eye disease, and normal visual acuity were enrolled as a control group. The refractive error group included children with refractive error [30]. The strabismus/amblyopia group included children with strabismus, with amblyopia, or both. These children were grouped together, as amblyopia is highly associated with strabismus [31], and children with amblyopia or with strabismus were found to have a significantly reduced functional vision and ER-QOL in English-speaking children [14–16]. Patients who had received or were currently undergoing treatment such as strabismus surgery, patching, and visual training were also included in this study. Moreover, those who had multiple eye conditions associated with amblyopia/strabismus, such as refractive error, anisometropia and manifest-latent nystagmus, were included in the strabismus/amblyopia group. Three children had other eye conditions, such as tilted disc syndrome ($n = 1$), morning glory syndrome ($n = 1$) and superficial punctate keratitis ($n = 1$). They were not included in the three subgroups (i.e., controls, refractive error, and strabismus/amblyopia groups). Data of these three participants were used in our overall analysis but were excluded when the difference between the three groups was analyzed.

Demographic and clinical data on all participants are summarized in Table 1. A subgroup of participants, 30 of 160, was selected randomly to have a retest in two weeks. The study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of Eye Hospital, Wenzhou Medical University.

Procedures

All clinical measurements were done by one of the three professional ophthalmologists (authors MP.X., HY.Y. and XP.Y.). They recorded clinical information (i.e., clinical examination results and diagnosis) in the electronic medical record of each patient. The data were collected via PedEyeQ-CN by one of the other three researchers (authors X.Y., LL.W. and R.Z.) who were not aware of the children's eye conditions. They only recorded basic information (i.e., name, age, gender) from the participant's clinical file. Other authors in this study (L.G. and Y.X.) who were not involved in previous clinical examinations nor data collection via PedEyeQ-CN matched the participants' questionnaires with their clinical records, and reviewed their eye conditions, diagnosis, and previous treatments.

All children underwent the following procedures: uncorrected visual acuity (UCVA), noncycloplegic autorefraction (Goaleye RM-9000; Shenzhen Aist Industrial Co., Ltd., China), PedEyeQ-CN, noncycloplegic subjective refraction, best-corrected visual acuity (BCVA), noncycloplegic retinoscopy, cover-uncover test, and slit-lamp examination. The cycloplegic subjective refraction and cycloplegic retinoscopy were used when children's BCVA was worse by two or more logarithm of the minimum angle of resolution (logMAR) lines than the age-referenced normal visual acuity. The simultaneous prism cover test and the prism and the alternate cover test were used to measure the angle deviation when children were diagnosed with strabismus by the cover-uncover test. Other clinical examinations, e.g., ocular fundus examination, were used depending on children's eye conditions. The visual acuity (UCVA and BCVA) was measured at distance (5 m) with a Chinese standard logarithm visual acuity E chart (GB 11533-2011) in an illuminated cabinet (WSVC-100, Wenzhou, China) and then converted to logMAR units. The description of the refractive error type, strabismus type, amblyopia type and previous treatment was based on the review of the medical record.

Definitions

Normal vision was defined when children had no refractive error (spherical equivalent refraction (SER) between -0.50D and +0.50D), eye disease, and normal visual acuity for age. The normal visual acuity for each year of age (i.e., age-referenced normal visual acuity) was defined based on previously published normal values [32]. Refractive error was diagnosed when there was a refractive error (< -0.50D or $> +0.50$D) [30] and abnormal uncorrected visual acuity, which could be corrected to age-referenced normal visual acuity, but no other eye conditions. Strabismus was diagnosed by the cover-uncover test (unilateral cover test) [33]. Amblyopia was diagnosed when there was an interocular BCVA (after optical correction) difference of two or more logMAR lines (unilateral amblyopia) or BCVA ≥ 0.10 logMAR in either eye (bilateral amblyopia) [31, 34].

PedEyeQ

The PedEyeQ (5–11 years old) had three sections (i.e., scales). The children were asked to complete the Child section (first scale); their parents were asked to complete the Proxy and Parent sections (second and third scales). Each item in the questionnaire had a frequency scale for responses: "never", "sometimes", and "all the time" (see Supplementary information for the full questionnaire).

The Child PedEyeQ had four distinct, separately scored domains (i.e., subscales): (1) functional vision, (2) bothered by eyes/vision, (3) social, and

Table 1. Demographic characteristics.

Characteristics	Total ($n = 160$)	Controls ($n = 32$)	Refractive error ($n = 77$)	Strabismus/ amblyopia ($n = 48$)
Gender (No. (%))				
Female	81 (50.63)	19 (59.38)	41 (53.25)	18 (37.50)
Age (mean (SD))	7.3 (1.63)	6.5 (0.98)	7.5 (1.70)	7.6 (1.79)
VA (logMAR, median (95%CI))				
Better eye	0.02 (0.031)	0.00 (0.003)	0.10 (0.055)	0.05 (0.029)
Worse eye	0.13 (0.039)	0.00 (0.003)	0.22 (0.057)	0.15 (0.067)
BCVA (logMAR, median (95%CI))				
Better eye	0.00 (0.008)	0.00 (0.003)	0.00 (0.013)	0.00 (0.019)
Worse eye	0.00 (0.018)	0.00 (0.003)	0.00 (0.014)	0.00 (0.046)
Type (No. (%))				
Myopia	67 (41.88)	N/A	67 (87.01)	N/A
Hyperopia	9 (3.75)	N/A	9 (11.69)	N/A
Anisometropia	1 (0.63)	N/A	1 (1.30)	N/A
Esotropia	4 (2.50)	N/A	N/A	3 (6.25)
Exotropia	9 (5.63)	N/A	N/A	8 (16.67)
Intermittent exotropia	21 (13.13)	N/A	N/A	19 (39.58)
Vertical	1 (0.63)	N/A	N/A	1 (2.83)
Strabismus amblyopia	2 (1.25)	N/A	N/A	2 (4.17)
Anisometropic amblyopia	8 (5.00)	N/A	N/A	8 (16.67)
Refractive error amblyopia	4 (2.50)	N/A	N/A	4 (8.33)
Mixed amblyopia	3 (1.88)	N/A	N/A	3 (6.25)
Others	3 (1.88)	N/A	N/A	N/A
Previous treatment (No. (%))				
No previous treatment	85 (53.13)	32 (100)	37 (48.05)	16 (33.33)
Glasses wear	63 (39.38)	N/A	40 (51.95)	23 (47.92)
Surgery	11 (6.88)	N/A	N/A	11 (22.92)
Patching	7 (4.38)	N/A	N/A	7 (14.58)
Visual training	2 (1.25)	N/A	N/A	2 (4.17)

N/A not applicable.

(4) frustration/worry. The Proxy PedEyeQ has 5 domains: (1) functional vision, (2) bothered by eyes/vision, (3) social, (4) frustration/worry, and (5) eye care. The Parent PedEyeQ had four domains: (1) impact on parent and family, (2) worry about child's eye condition, (3) worry about child's self-perception and interactions, and (4) worry about child's functional vision [10].

We used the same design of questionnaires as the PedEyeQ in PedEyeQ-CN. All participants completed questionnaires on paper in the hospital. For parents and older children, questionnaires were self-administered; for younger children, questionnaires were completed with the help of a researcher. This procedure was conducted following the original English version of PedEyeQ [15], as younger children, for example 5-year-old children, might have problems in reading. In particular, the researcher read the items out without any explanation or example. The sub-group participants completed the retest questionnaires by an electronic version of the questionnaire via their own smart phones at home. The digital format was used because two weeks are too short for the reexamination for children with eye conditions (according to Chinese Guidelines for Clinical Diagnosis and Treatment of Ophthalmology), and the cooperation of returning to the hospital in children without eye conditions was also poor.

Analysis

For each participant, on each distinct PedEyeQ-CN domain, Rasch scores were calculated using published Rasch lookup tables and converted to 0 (worst) to 100 (best). Domain scores were calculated as a mean of all items.

Shapiro-Wilks test was used to assess the normality of the dataset [35]. Non-parametric test (e.g., Spearman's correlation analysis) was used when data were not normally distributed. Internal consistency (Cronbach's α) was used as a measure of the extent to which items within a single domain are related within the domain. The optimal range of Cronbach α is ≥ 0.70. To further determine scale homogeneity (i.e., the extent to which items within the same domain reflect a single underlying construct), the item-scale correlation coefficient was calculated. To do so, we computed the domain score based on the items within one domain and the Rasch Table using the data of 160 participants. Next, we calculated the correlation of each item's score to the domain score to calculate item-scale correlation coefficient by using Spearman's correlation analysis. A coefficient (r) of ≥ 0.40 was considered satisfactory and ≥ 0.3 was considered acceptable [36, 37].

We retested 30 out of 160 participants two weeks after their first testing session to determine the test-retest reliability (i.e., intraclass correlation coefficient) of the questionnaire. The time point was set at two weeks as this was short enough to avoid changes in visual acuity and long enough for participants not to remember the answers. Correlations between test-answer score of each domain and retest-answer score (i.e., intraclass correlation) were analyzed by using Spearman's correlation analysis. Intraclass correlation coefficients (r) above 0.70 were considered satisfactory [38].

Validity represents the extent to which the results reflect the real situation (i.e., whether the test measures what it is supposed to measure). We firstly assessed it by comparing the scores of each domain and the whole score by Spearman correlation analysis. If the correlations between the scores of each domain were lower than that between the score of each domain and the total score, they were considered to be satisfactory. Then we assessed it by comparing PedEyeQ-CN scores between normal controls, refractive error, and strabismus/amblyopia groups (excluded 3 children with other eye conditions, i.e., n = 157). The difference between groups was analyzed by a comparison of median PedEyeQ-CN scores using

Table 2. Item–scale correlation of child, proxy, and parent PedEyeQ-CN.

	1	2	3	4	5	6	7	8	9	10
Child										
Functional vision	0.61	0.68	0.53	0.54	0.62	0.32	0.53	0.52	0.34	0.52
Bothered by eyes/vision	0.53	0.37	0.69	0.46	0.53	0.50	0.40	0.55	0.66	0.70
Social	0.45	0.65	0.44	0.44	0.32	0.57	0.73	0.37	0.43	0.77
Frustration/worry	0.52	0.51	0.64	0.50	0.43	0.49	0.35	0.70	0.59	0.63
Proxy										
Functional vision	0.67	0.78	0.64	0.63	0.45	0.65	0.61	0.66	0.37	0.53
Bothered by eyes/vision	0.51	0.59	0.73	0.43	0.55	0.35	0.75	0.72	0.49	0.35
Social	0.73	0.84	0.66	0.73	0.71	0.62	0.75	0.73	–	–
Frustration/worry	0.62	0.81	0.85	0.82	0.80	–	–	–	–	–
Eye care	0.73	0.66	0.76	0.39	0.68	0.76	–	–	–	–
Parent										
Impact on parent and family	0.44	0.69	0.62	0.73	0.67	0.70	0.75	0.57	0.72	0.78
Worry about child's eye condition	0.76	0.77	0.74	0.73	0.76	0.81	0.82	0.75	0.78	0.76
Worry about child's self-perception and interactions	0.69	0.72	0.66	0.70	0.73	0.77	0.80	–	–	–
Worry about child's functional vision	0.80	0.83	0.84	0.84	0.86	0.84	0.74	0.79	–	–

nonparametric Kruskal-Wallis test. P values were corrected by Bonferroni correction when comparing between different groups for multiple comparisons, but that were not adjusted within domains.

Patients' demographic factors on PedEyeQ-CN were assessed by analyzing the impact of gender and visual acuity. The difference of domain scores between boys and girls was analyzed by comparing the median PedEyeQ-CN scores using nonparametric Kruskal-Wallis test. Correlation between test score and visual acuity was analyzed using Spearman's correlation analysis. A weak correlation was interpreted as $-0.30 < \rho \le -0.10$, and a moderate correlation was interpreted as $-0.70 < \rho \le -0.30$ [39, 40].

All analyses were conducted at the 5% significance level (two-sided test with $P < 0.05$ [15] as the criterion for statistical significance) using SPSS Statistics Version 25 (IBM, Armonk, NY, USA).

RESULTS

Item analysis

The item-scale correlations of each domain in Child, Proxy and Parent PedEyeQ-CN scales are shown in Table 2. For Child PedEyeQ-CN, the item-scale correlations coefficients were generally high, ranging from 0.43 to 0.76. Items 6, 9, 12, 17, 25, 28, and 37 had a correlation coefficient at 0.30-0.40. For Proxy PedEyeQ-CN, the item-scale correlations coefficients were also generally high, ranging from 0.43 to 0.85. Items 9, 16, 20, and 37 had a correlation coefficient at 0.30-0.40. For Parent PedEyeQ-CN, the item-scale correlations coefficients were all high, ranging from 0.44 to 0.86.

Reliability

Cronbach's α coefficient was used to define internal consistency. Cronbach's α of Child PedEyeQ-CN ranged from 0.76 to 0.81, that of Proxy PedEyeQ-CN ranged from 0.83 to 0.93, and that of Parent PedEyeQ-CN ranged from 0.91 to 0.94, which are all greater than 0.70 (Table 3). The test-retest reliability for each participant's score in all participants was high, with an intraclass correlation coefficient above 0.80 in all domains. The test-retest reliability in children with eye conditions was also calculated and ranged from 0.75 to 0.92 (Table 3). These findings indicate a good reliability.

Validity

Correlation coefficients were calculated to compare the scores of each domain and the whole score. Table 4 shows that the correlations between the scores of each domain for the whole group (Child: ρ ranged from 0.57 to 0.78; Proxy: ρ ranged from 0.47 to 0.75; Parent: ρ ranged from 0.57 to 0.79) were lower than that between the score of each domain and the total score (the average score of all domains; Child: ρ ranged from 0.85 to 0.88; Proxy: ρ ranged from 0.71 to 0.86; Parent: ρ ranged from 0.79 to 0.92). For the children with eye conditions, the correlations were lower between scores of each domain (Child: ρ ranged from 0.53 to 0.77; Proxy: ρ ranged from 0.46 to 0.74; Parent: ρ ranged from 0.53 to 0.80) than that between the score of each domain and the total score (Child: ρ ranged from 0.81 to 0.87; Proxy: ρ ranged from 0.74 to 0.84; Parent: ρ ranged from 0.79 to 0.92). These findings suggest an adequate validity.

We also found that the scores for children with strabismus/amblyopia and their parents were significantly lower in all domains compared with those of normal controls (all domains in all three scales; Fig. 1 and Table S1). Scores for children with refractive error and their parents were also significantly lower in most domains (3 out of 4 domains in Child scale; 5 out of 5 domains in Proxy scale; and 1 domain in Parent scale; Fig. 1 and Table S1) than those from normal controls. When the scores of children with strabismus/amblyopia and children with refractive error were compared, we found that the strabismus/amblyopia group only had a lower score for frustration/worry ($P = 0.048$) in Child PedEyeQ-CN, and worry about child's self-perception and interaction ($P = 0.001$) in Parent PedEyeQ-CN (See Fig. 1 and Table S1). These findings suggested that PedEyeQ-CN could provide information about the impacts of eye conditions on functional vision and ER-OQL.

Patients' demographic factors on PedEyeQ-CN

There was no significant difference in most domain scores due to gender (Child PedEyeQ-CN: functional vision, $P = 0.280$; bothered by eyes/vision, $P = 0.883$; social, $P = 0.719$; frustration/worry, $P = 0.456$; Proxy PedEyeQ-CN: bothered by eyes/vision, $P = 0.329$; social, $P = 0.914$; frustration/worry, $P = 0.927$; eye care, $P = 0.862$; Parent PedEyeQ-CN: impact on parent and family, $P = 0.830$; worry about child's eye condition, $P = 0.765$; worry about child's self-perception and interactions, $P = 0.731$; worry about child's functional vision, $P = 0.528$) except functional vision in Proxy PedEyeQ-CN ($P = 0.045$; See Fig. S1).

We also computed spearman correlations between visual acuity of the worse eye and scores of domains. Here, visual acuity corresponds to the habitual uncorrected vision, which was uncorrected, not fully corrected or fully corrected visual acuity

Table 3. Internal consistency (Cronbach α) and test-retest reliability of PedEyeQ-CN domains.

Domain (items)	Cronbach's α ($n = 160$)	Test-retest reliability	
		Total ($n = 30$)	Children with eye conditions ($n = 24$)
Child			
Functional vision (10)	0.76	0.88	0.88
Bothered by eyes/vision (10)	0.81	0.81	0.86
Social (10)	0.77	0.81	0.84
Frustration/worry (10)	0.77	0.85	0.89
Proxy			
Functional vision (10)	0.84	0.86	0.89
Bothered by eyes/vision (10)	0.83	0.82	0.75
Social (8)	0.93	0.80	0.85
Frustration/worry (5)	0.86	0.90	0.88
Eye care (6)	0.78	0.81	0.85
Parent			
Impact on parent and family (10)	0.91	0.80	0.84
Worry about child's eye condition (10)	0.93	0.90	0.91
Worry about child's self-perception and interactions (7)	0.91	0.84	0.85
Worry about child's functional vision (8)	0.94	0.91	0.92

depending on indivuals' eye condition in daily life. We found moderate correlations in two out of 13 domains (e.g., functional vision in Child scale, $\rho = -0.33$, $P < 0.001$), and weak correlations in eight out of 13 domains (e.g., bothered by eye and vision in Child scale, $\rho =$ -0.28, $P < 0.001$) in all participants (Fig. S2A). The correlations between visual acuity and PedEyeQ-CN scores in children with eye conditions (i.e., refractive error, strabismus, amblyopia, and other eye diseases) were further computed. Weak correlations were found in two functional vision domains (e.g., functional vision in Child scale, $\rho =$ -0.25, $P = 0.005$; Fig. S2B).

DISCUSSION

In this study, we translated the PedEyeQ (English) into PedEyeQ-CN (Chinese) and evaluated whether the translated version could effectively inform about the impact of Chinese children's eye conditions on the population's functional vision and ER-QOL. 160 children (including normal controls, refractive error, strabismus, amblyopia, and other eye conditions) and their parents were recruited in this study. Overall, the data presented in our study indicates that the PedEyeQ-CN is culturally appropriate for assessing functional vision and ER-QOL among 5-11 years old children in China and discriminating between normal children and children with eye conditions.

Cronbach's α was found to be greater than 0.7 for all domians in the Child, Proxy and Parent questionnaires. This finding indicates that PedEyeQ-CN has a high internal consistency (i.e., internal homogeneity). The test reliability (i.e., person reliability by Rasch analysis, reflecting internal consistency) of original English PedEyeQ [10] is analogous to Cronbach's α of present study. The test reliability of PedEyeQ (5-11 years old) ranged from 0.50 to 0.84 [10], which were comparable with our results of Cronbach's α. The internal consistency was found to be lower in the Child scale compared with the Proxy and Parent scales both in translated PedEyeQ-CN (Cronbach's α) and in original PedEyeQ (test reliability). These results demonstrate that PedEyeQ-CN has as good reliability as the one of the original English version. All domains had intraclass correlation coefficients (the indication of test-retest reliability) greater than 0.80 in all 30 participants who finished their second (i.e., retest) session. The intraclass correlation was also robust (ranged from 0.85 to 0.92) in children with eye conditions (23 participants; excluding 7 participants with normal vision). The different formats of questionnaire (paper vs. digital versions) were used in the first and second sessions (test vs. retest) as considering the difficulty for participants of returning to the hospital and also considering that both of these two formats have been used in previous study [15]. The different formats of administration might add noise on the test-retest results, which in turn underestimate the correlation coefficient. Since the intraclass correlation was over 0.80 in all subscales in the current study, we thus believe that our results indicate a good test-retest reliability of PedEyeQ-CN. Our findings suggest that PedEyeQ-CN is a reliable and stable test for evaluating the functional vision and ER-QOL of children with different eye conditions in China.

We mostly observed satisfactory item-scale correlations, which means that all items show good correlations with corresponding domains. The translated items of PedEyeQ-CN in each domain seem to reflect the domains in PedEyeQ as they had been originally designed for (i.e., functional vision and ER-QOL), since the different domains in the three scales of PedEyeQ were designed to assess functional vision and ER-QOL in children and their parents [41]. Also, the domain-domain correlations were all found to be lower than domain-scale correlations both in all participants and in children with eye conditions, suggesting that each domain reflects different aspects.

We found that the scores of children with refractive error or strabismus/amblyopia and their parents were significantly lower than those of children with normal vision and their parents. This result agrees with previous studies using PedEyeQ in English-speaking children with visual impairment [13] and children with strabismus and anisometropia [14], suggesting that children with eye conditions could have worse scores in functional vision and ER-QOL than normal children. Our results thus demonstrate that PedEyeQ-CN has as good validity as the original English version (PedEyeQ). Moreover, children with strabismus/amblyopia had worse ER-QOL compared with the children with refractive error (i.e., lower scores in frustration/worry in Child PedEyeQ-CN; lower scores in worry about child's self-perception and interaction in Parent PedEyeQ-CN). This might be because refractive error is now a common eye condition in China. The prevalence of refractive error (myopia) exceeds 60% among 12 years old children in China, reaches nearly 80% among 16 years old children, and surpasses 90% in university students [42–44]. So, children with myopia are

Table 4. Correlations between scores for each domain and the total score.

			1	2	3	4	
Child							
	1	Functional vision	1				
	2	Bothered by eyes/vision	0.78*** (0.74***)	1			
	3	Social	0.62*** (0.54***)	0.68*** (0.66***)	1		
	4	Frustration/worry	0.57*** (0.53***)	0.69*** (0.68***)	0.73*** (0.77***)	1	
		Total	0.85*** (0.81***)	0.88*** (0.87***)	0.87*** (0.86***)	0.87*** (0.87***)	
Proxy			1	2	3	4	5
	1	Functional vision	1				
	2	Bothered by eyes/vision	0.75*** (0.74***)	1			
	3	Social	0.47*** (0.42***)	0.57*** (0.58***)	1		
	4	Frustration/worry	0.51*** (0.47***)	0.48*** (0.46***)	0.56*** (0.55***)	1	
	5	Eye care	0.53*** (0.50***)	0.57*** (0.56***)	0.58*** (0.58***)	0.64*** (0.62***)	1
		Total	0.76*** (0.75***)	0.75*** (0.76***)	0.71*** (0.74***)	0.86*** (0.83***)	0.85*** (0.84***)
Parent			1	2	3	4	
	1	Impact on parent and family	1				
	2	Worry about child's eye condition	0.68*** (0.63***)	1			
	3	Worry about child's self-perception and interactions	0.57*** (0.53***)	0.63*** (0.63***)	1		
	4	Worry about child's functional vision	0.67*** (0.65***)	0.79*** (0.80***)	0.68*** (0.63***)	1	
		Total	0.79*** (0.79***)	0.92*** (0.92***)	0.80*** (0.81***)	0.92*** (0.92***)	

Spearman coefficient test. Numbers in brackets represent results in children with eye conditions. *** $P < 0.001$.

more like their peers than children with strabismus, which means having myopia is not the exception now in China. Thus, children with refractive error and their parents would have less concern than children with strabismus/amblyopia, and the impact of eye disease on their parent's ER-QOL would be less. In the present study, many children with refractive error were first diagnosed (i.e., with uncorrected refractive error); this might explain why children with refractive error and with strabismus/amblyopia have no significant difference in their functional vision. These results also suggest that PedEyeQ-CN is a sensitive tool to assess the impact of different eye diseases on ER-QOL.

We have also considered the participants' demographic factors when assessing the validity of PedEyeQ-CN. We found no significant difference between the scores of male and female children. The correlations between PedEyeQ-CN and visual acuity of the worse eye were computed both in all participants and only in children with eye conditions (i.e., refractive error, strabismus, amblyopia, and other eye conditions). Significant correlations between PedEyeQ-CN scores and visual acuity were found in 10 out of 13 domains in all participants, but only in functional vision domain in Child and Proxy scales in children with eye conditions. Leske et al. [18], have reported significant correlations between functional vision, ER-QOL, and visual acuity in children with eye conditions. However, we did not observe significant correlation between ER-QOL and visual acuity in our study. As a possible explanation, the visual acuity of participants in the present study was better than that in Leske et al.,'s study. Also, Leske et al., included 397 children with various eye conditions, whereas we included 128 participants and the majority of them had a refractive error. The low range in visual acuity and eye conditions might have affected the correlations. Another reason could be that the Leske et al., used uncorrected visual acuity as their primary measure, whereas we referred to everyday vision. However, the results of reduced ER-QOL scores in PedEyeQ-CN and unrelated with visual acuity suggest that children's eye condition affects ER-QOL of children and their family even when children have a good visual acuity, e.g., with glasses. Our results reveal that visual function and ER-QOL assessments by PedEyeQ-CN go beyond visual acuity measurement in characterizing the impact of children's eye conditions.

Limitations

This study has limitations. Since the participants were recruited from one hospital, even if some participants (32 of 160) came for routine eye examination, there might have been a selection bias because some parents might have had a tendency to self-select and be more concerned. Thus, it would be more representative to find a general population in a future study. In addition, we wanted to further analyze the difference between children with uncorrected refractive error and corrected refractive error, between children with glasses (fully corrected) and normal controls (i.e., normal vision without glasses), between children who had strabismus surgery before (i.e., clinically straightened) and had no surgery, between strabismus and amblyopia to assess the impact of refractive error, glasses wear, strabismus surgery, and eye diseases (strabismus and amblyopia). However, we could not get reliable results by nonparametric Kruskal-Wallis test since our sample size of each subgroup was not adequate to do so. Thus, one needs to investigate the scores of PedEyeQ-CN in children with different eye conditions in future with a larger sample size. Moreover, in the present study, visual acuity was the only factor we considered for the visual function. Other visual function measurements, such as contrast sensitivity [45], stereopsis [45, 46], binocular functions [47–49], temporal synchrony [50], motion perception [51], and other vision-related function measurements, such as reading speed and motor skills [14], might also be correlated with children's functional vision and ER-QOL.

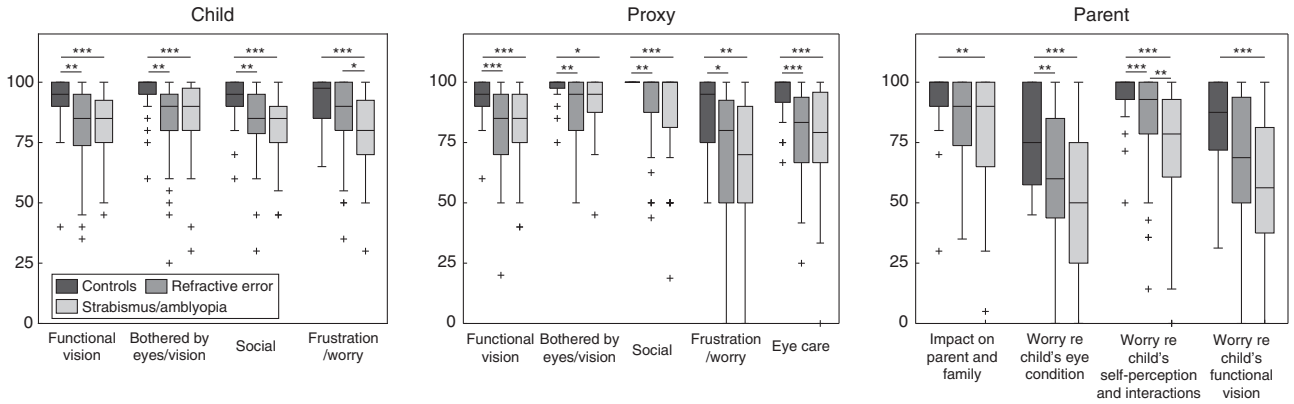

Fig. 1 Scores for normal controls, refractive error, and strabismus/amblyopia children and their parents. Child PedEyeQ-CN domains include functional vision, bothered by eyes/vision, social, and frustration/worry. Proxy PedEyeQ-CN domains include functional vision, bothered by eyes/vision, social, frustration/worry, and eye care. Parent PedEyeQ-CN domains include the impact on parent and family, worry about child's eye condition, worry about child's self-perception and interactions, and worry about child's functional vision. The boxes represent first quartile, median, and third quartile values; whiskers represent extreme values; crosses represent outliners. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

CONCLUSION

In summary, the translated Chinese version of the Pediatric Eye Questionnaire (PedEyeQ-CN) is a valuable method that provides valuable information about children (aged 5-11 years old) with various eye conditions. Using the recently translated PedEyeQ-CN, we found children with refractive error or strabismus/amblyopia have impaired functional vision and reduced ER-QOL across distinct domains relative to those of normal controls. Parents of children with eye conditions also experienced a reduced quality of life. Also, strabismus/amblyopia affected ER-QOL of children and their parents more so than refractive error. Significant correlations were found between functional vision scores and visual acuity of the worse eye, but not between ER-QOL and visual acuity; this suggests that the pediatric eye questionnaire in Chinese could provide more information of impact of children's eye condition than visual acuity and is greatly needed to assess the functional vision and ER-QOL of children. These findings can help us to use PedEyeQ-CN in Chinese populations and increase our understanding about how the eye conditions affect children and their families.

Supplementary information is available at Eye's website.

SUMMARY

What was known before

- Pediatric Eye Questionnaire (PedEyeQ) has now been considered as an useful assessment in the clinic and clinical research settings in English-speaking countries.

What this study adds

- We translated PedEyeQ from English to Chinese (PedEyeQ-CN) and evaluated the reliability and validity of PedEyeQ-CN. We demonstrated that PedEyeQ-CN was a reliable and stable method which could provide valuable information about functional vision and ER-QOL of Chinese children and their family.

DATA AVAILABILITY

All data reported in this study will be available from the corresponding authors (Jiawei Zhou: zhoujw@mail.eye.ac.cn; or Xinping Yu: yu-xinping@163.com) upon request.

REFERENCES

1. Chan CW, Wong D, Lam CL, McGhee S, Lai WW. Development of a Chinese version of the National Eye Institute Visual Function Questionnaire (CHI-VFQ-25) as a tool to study patients with eye diseases in Hong Kong. Br J Ophthalmol. 2009;93:1431–1436.
2. Stein JD. Disparities between ophthalmologists and their patients in estimating quality of life. Curr Opin Ophthalmol. 2004;15:238–243.
3. Birch EE, Castañeda YS, Cheng-Patel CS, Morale SE, Kelly KR, Beauchamp CL, et al. Self-perception in children aged 3 to 7 years with amblyopia and its association with deficits in vision and fine motor skills. JAMA Ophthalmol. 2019;137:499–506.
4. Webber AL, Wood JM, Gole GA, Brown B. The effect of amblyopia on fine motor skills in children. Investigative Ophthalmol Vis Sci. 2008;49:594–603.
5. Grant S, Suttle C, Melmoth DR, Conway ML, Sloper JJ. Age-and stereovision-dependent eye–hand coordination deficits in children with amblyopia and abnormal binocularity. Investigative Ophthalmol Vis Sci. 2014;55:5687–5701.
6. Kelly KR, Jost RM, De La Cruz A, Birch EE. Multiple-choice answer form completion time in children with amblyopia and strabismus. JAMA Ophthalmol. 2018;136:938–941.
7. Suttle CM, Melmoth DR, Finlay AL, Sloper JJ, Grant S. Eye–hand coordination skills in children with and without amblyopia. Investigative Ophthalmol Vis Sci. 2011;52:1851–1864.
8. Gagnon-Roy M, Jasmin E, Camden C. Social participation of teenagers and young adults with developmental co-ordination disorder and strategies that could help them: results from a scoping review. Child: care, health Dev. 2016;42:840–851.
9. Zwicker JG, Harris SR, Klassen AF. Quality of life domains affected in children with developmental coordination disorder: a systematic review. Child: care, health Dev. 2013;39:562–580.
10. Hatt SR, Leske DA, Castañeda YS, Wernimont SM, Liebermann L, Cheng-Patel CS, et al. Development of pediatric eye questionnaires for children with eye conditions. Am J Ophthalmol. 2019;200:201–217.
11. Varni JW, Seid M, Rode CA The PedsQL™: measurement model for the pediatric quality of life inventory. Medical Care. 1999;37:126–139.
12. Varni JW, Seid M, Kurtin PS PedsQL™ 4.0: Reliability and validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in healthy and patient populations. Medical Care. 2001;39:800–812.
13. Leske DA, Hatt SR, Castañeda YS, Wernimont SM, Liebermann L, Cheng-Patel CS, et al. Validation of the Pediatric Eye Questionnaire in Children with Visual Impairment. Am J Ophthalmol. 2019;208:124–132.
14. Birch EE, Castañeda YS, Cheng-Patel CS, Morale SE, Kelly KR, Jost RM, et al. Associations of Eye-Related Quality of Life With Vision, Visuomotor Function, and Self-Perception in Children With Strabismus and Anisometropia. Investigative Ophthalmol Vis Sci. 2020;61:22.
15. Hatt SR, Leske DA, Castañeda YS, Wernimont SM, Liebermann L, Cheng-Patel CS, et al. Association of Strabismus With Functional Vision and Eye-Related Quality of Life in Children. JAMA Ophthalmol. 2020;138:528–535.
16. Hatt SR, Leske DA, Castañeda YS, Wernimont SM, Liebermann L, Cheng-Patel CS, et al. Understanding the impact of residual amblyopia on functional vision and eye-related quality of life using the PedEyeQ. Am J Ophthalmol. 2020;218:173–181.
17. Leske DA, Hatt SR, Castañeda YS, Wernimont SM, Liebermann L, Cheng-Patel CS, et al. Eye-related quality of life and functional vision in children wearing glasses. J Am Assoc Pediatr Ophthalmol Strabismus. 2020;24:91–e1.

18. Leske DA, Hatt SR, Wernimont SM, Castañeda YS, Cheng-Patel CS, Liebermann L, et al. Association of visual acuity with eye-related quality of life and functional vision across childhood eye conditions. Am J Ophthalmol. 2020;223:220–228.
19. Bai Y, Yi H, Zhang L, Shi Y, Ma X, Congdon N, et al. An investigation of vision problems and the vision care system in rural China. Southeast Asian J tropical Med public health. 2014;45:1464.
20. Xu L, Ma Y, Yuan J, Zhang Y, Wang H, Zhang G, et al. COVID-19 quarantine reveals that behavioral changes have an effect on myopia progression. Ophthalmology. 2021;128:1652–1654.
21. Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, et al. The epidemics of myopia: aetiology and prevention. Prog retinal eye Res. 2018;62:134–149.
22. West SK, Munoz B, Rubin GS, Schein OD, Bandeen-Roche K, Zeger S, et al. Function and visual impairment in a population-based study of older adults. The SEE project. Salisbury Eye Evaluation. Investigative Ophthalmol Vis Sci. 1997;38:72–82.
23. Nutheti R, Shamanna BR, Nirmalan PK, Keeffe JE, Krishnaiah S, Rao GN, et al. Impact of impaired vision and eye disease on quality of life in Andhra Pradesh. Investigative Ophthalmol Vis Sci. 2006;47:4742–4748.
24. Wen G, McKean-Cowdin R, Varma R, Tarczy-Hornoch K, Cotter SA, Borchert M, et al. General health-related quality of life in preschool children with strabismus or amblyopia. Ophthalmology 2011;118:574–580.
25. Chai Y, Shao Y, Lin S, Xiong KY, Chen WS, Li YY, et al. Vision-related quality of life and emotional impact in children with strabismus: a prospective study. J Int Med Res. 2009;37:1108–1114.
26. Sim B, Yap G-H, Chia A. Functional and psychosocial impact of strabismus on Singaporean children. J Am Assoc Pediatr Ophthalmol Strabismus. 2014;18:178–182.
27. Organization WH.Process of translation and adaptation of instruments. Geneva: World Health Organization 2016; 2018.
28. Wang J, Ying G, Fu X, Zhang R, Meng J, Gu F, et al. Prevalence of myopia and vision impairment in school students in Eastern China. BMC Ophthalmol. 2020;20:1–10.
29. Wang J, Li Y, Musch DC, Wei N, Qi X, Ding G, et al. Progression of myopia in school-aged children after COVID-19 home confinement. JAMA Ophthalmol. 2021;139:293–300.
30. Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. Investigative Ophthalmol Vis Sci. 1997;38:334–340.
31. Christiansen SP, Lee KA, Morse CL, Repka MX, Sprunger DT, Melia M, et al. Amblyopia preferred practice pattern (R). Ophthalmology 2018;125:P105–P142.
32. Anon. Chinese Ophthalmology Society. Guidelines for amblyopia diagnosis. Chin J Ophthalmol 2011;47:768.
33. Grosvenor TP.Primary care optometry. Elsevier Health Sciences; 2007.
34. Birch EE. Amblyopia and binocular vision. Prog retinal eye Res. 2013;33:67–84.
35. Mendes M, Pala A. Type I error rate and power of three normality tests. Pak J Inf Technol. 2003;2:135–139.
36. Globe D, Varma R, Azen SP, Paz S, Yu E, Preston-Martin S. Psychometric performance of the NEI VFQ-25 in visually normal Latinos: the Los Angeles Latino Eye Study. Investigative Ophthalmol Vis Sci. 2003;44:1470–1478.
37. Jaarsma T, Årestedt KF, Mårtensson J, Dracup K, Strömberg A. The European Heart Failure Self-care Behaviour scale revised into a nine-item scale (EHFScB-9): a reliable and valid international instrument. Eur J heart Fail. 2009;11:99–105.
38. Mangione CM, Lee PP, Pitts J, Gutierrez P, Berry S, Hays RD. Psychometric properties of the National Eye Institute visual function questionnaire (NEI-VFQ). Arch Ophthalmol. 1998;116:1496–1504.
39. Akoglu H. User's guide to correlation coefficients. Turkish J Emerg Med. 2018;18:91–93.
40. Ratner B. The correlation coefficient: Definition. DM Stat-1 Artic. 2013;49:50.
41. Hatt SR, Leske DA, Bradley EA, Cole SR, Holmes JM. Development of a quality-of-life questionnaire for adults with strabismus. Ophthalmology 2009;116:139–144. e5.
42. Sun J, Zhou J, Zhao P, Lian J, Zhu H, Zhou Y, et al. High prevalence of myopia and high myopia in 5060 Chinese university students in Shanghai. Investigative Ophthalmol Vis Sci. 2012;53:7504–7509.
43. Li S-M, Liu L-R, Li S-Y, Ji Y-Z, Fu J, Wang Y, et al. Design, methodology and baseline data of a school-based cohort study in Central China: the Anyang Childhood Eye Study. Ophthalmic Epidemiol. 2013;20:348–359.
44. Wu JF, Bi HS, Wang SM, Hu YY, Wu H, Sun W, et al. Refractive error, visual acuity and causes of vision loss in children in Shandong, China. The Shandong Children Eye Study. PloS one. 2013;8:e82763.
45. Datta S, Foss AJ, Grainge MJ, Gregson RM, Zaman A, Masud T, et al. The importance of acuity, stereopsis, and contrast sensitivity for health-related quality of life in elderly women with cataracts. Investigative Ophthalmol Vis Sci. 2008;49:1–6.
46. Kuang TM, Hsu W-M, Chou CK, Tsai SY, Chou P. Impact of stereopsis on quality of life. Eye 2005;19:540–545.
47. Gong L, Reynaud A, Wang Z, Cao S, Lu F, Qu J, et al. Interocular suppression as revealed by dichoptic masking is orientation-dependent and imbalanced in amblyopia. Investigative Ophthalmol Vis Sci. 2020;61:28.
48. Zhou J, Reynaud A, Yao Z, Liu R, Feng L, Zhou Y, et al. Amblyopic suppression: Passive attenuation, enhanced dichoptic masking by the fellow eye or reduced dichoptic masking by the amblyopic eye? Investigative Ophthalmol Vis Sci. 2018;59:4190–4197.
49. Huang C-B, Zhou J, Zhou Y, Lu Z-L. Contrast and phase combination in binocular vision. PloS one. 2010;5:e15075.
50. Tao C, Wu Y, Gong L, Chen S, Mao Y, Chen Y, et al. Abnormal monocular and dichoptic temporal synchrony in adults with amblyopia. Investigative Ophthalmol Vis Sci. 2019;60:4858–4864.
51. Albright TD, Stoner GR. Visual motion perception. Proc Natl Acad Sci 1995;92:2433–2440.

ACKNOWLEDGEMENTS

We would like to thank Dr. Eileen E. Birch for detailed and helpful discussions throughout this study; and Seung Hyun Min for valuable comments and careful review of the manuscript.

AUTHOR CONTRIBUTIONS

LG, XPY, FL, JQ, and JWZ conceived the experiment. XY, LLW, and RZ collected data via PedEyeQ-CN. MPX, HYY, and XPY conducted clinical measurements. LG and YX matched the questionnaire data with clinical records. LG, SQC, and ZFH analyzed and interpreted the data. LG, XPY, and JWZ wrote the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This work was supported by the National Key Research and Development Program of China Grant (2020YFC2003800), the Natural Science Foundation for Distinguished Young Scholars of Zhejiang Province, China (LR22H120001), and the National Natural Science Foundation of China Grant (NSFC 31970975) to Jiawei Zhou; the National Natural Science Foundation of China Grant (NSFC 82070995) to Xinping Yu; and the Zhejiang Medical Health Science and Technology Project (2020KY656) to Zhifen He.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41433-022-02157-5.

Correspondence and requests for materials should be addressed to Xinping Yu or Jiawei Zhou.

Reprints and permission information is available at http://www.nature.com/reprints

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.