

Investigation of children's habits of smartphone usage and parental awareness of myopia control in underdeveloped areas of China

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Abstract

• **AIM:** To investigate the behaviors of smartphone usage and parental knowledge of vision health among primary students in the rural areas of China.

• **METHODS:** In this school-based, cross-sectional study, a total of 52 606 parents of students from 30 primary schools in the Xingguo County were investigated through an online questionnaire from July 2020 to August 2020. The self-designed questionnaire contained three parts: the demographic factors of both children and parents, parental knowledge and attitude toward myopia, and the preventive treatment of myopia.

• **RESULTS:** A total of 52 485 appropriately answered questionnaires were received, showing an effective response rate of 95.1%. The average age of the primary students was 10.1±0.98y and the prevalence of myopia among the primary students was 40.3%. The age of myopia occurrence in elementary students was significantly correlated with the parents' educational level (95%CI: 0.82-0.98, $P=0.013$), children's gender (95%CI: 1.08-1.20, $P<0.001$), school location (county or countryside) (95%CI: 0.59-0.66, $P<0.001$), children's smartphone ownership (95%CI: 1.09-1.26, $P<0.001$), and the average time spent on smartphone per day (95%CI: 0.78-0.88, $P<0.001$). School location in the county town, high family income, and high parents'

educational level significantly affected both parents' myopia awareness and children's vision-threatening behaviors ($P<0.01$). Left-behind children showed a higher incidence of vision-threatening habits than those who lived with their parents ($P<0.01$).

• **CONCLUSION:** The results reveal the current situation of myopia development among rural primary school students and their parents. This survey will serve as a guidance for designing myopic prevention policies in the rural areas of China.

• **KEYWORDS:** myopia; prevalence; rural China; smartphone use; left-behind children

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INTRODUCTION

Myopia is the leading cause of visual impairment worldwide. With 90% prevalence rates among young adults in parts of East and Southeast Asia, myopia poses as a major public health concern and burden for health agencies in these countries^[1]. Public health stakeholders particularly face a multitude of challenges in curbing myopia development in children as the contributing factors are multifaceted. Previous studies concerning myopic prevalence and risk factors have revealed that limited outdoor activity, long durations of near vision work, intensive education^[1], use of digital devices^[2-3], parental myopia, and parental attitudes toward visual health^[4], can possibly influence the development of myopia in children^[5]. Previous studies have reported early myopic onset in younger children^[6-7], with the exacerbating changes in these environmental and demographic factors being the causative factors.

Digital devices, especially smartphones, have significantly become more prevalent among children^[8]. Previous research

showed that smartphone usage in all digital devices was the highest among adolescents^[8], reporting a usage of 162min/d in the US^[9] and 264min/d in Singapore^[8]. Moreover, multimedia teaching via mobile devices, including online classes and digital homework, have become more common among students, further contributing to the increase of screen time and exposure to greater risk of visual impairment^[10]. Developing countries, such as China, are not exceptional to these changes. For example, a recent study showed that smartphone screen time among young children (8-10y) averaged 180min/d on the weekends in an urban area in China^[11]. This trend of growing screen time in children has drawn significant concern from relevant authorities in China over the detrimental effect on vision, such as triggering myopia onset.

Although myopia in children is more common in the urban areas of China^[6], a recent report showed that prevalence rates of myopia have been increasing at a faster rate in rural areas^[10]. The rural population comprises a very significant part of China, with more than 929 million people or nearly 70% of the total population living in rural villages or townships^[12]. Furthermore, conditions in rural areas are notably different from that in urban areas, making myopia prevention comparatively difficult. Healthcare resources, for one, are much scarcer and outdated in rural areas^[13], and the increase in smartphone usage among children in rural areas may exacerbate these current circumstances. In fact, studies have reported that smartphone usage in some rural areas have even exceeded smartphone usage in urban areas^[14-15]. Thus, myopia prevention is becoming urgently necessary in the rural areas of China. In that regard, parents play one of the key roles in early-stage myopic prevention and control, since their vision health knowledge and attitudes may exert subtle influence on the environmental factors around children^[16-17]. However, many parents in the rural areas possess a lack of proper education or disadvantaged economics status, despite their concern for the visual health of their children.

Previous studies have shown that parents in urban areas exhibited better knowledge regarding vision health and were more concerned regarding myopia in their children, as compared to that among parents in rural areas^[2]. Moreover, a portion of rural children, aptly named “left-behind children,” have parents who are migrant workers in urban cities, and they are thus brought up by grandparents or other close relatives instead^[18]. According to a study, there are almost 69.7 million “left-behind children” in China^[18], further impeding the myopia preventative efforts in the rural areas. In addition, it may be difficult to engage the guardians of these “left-behind children” in preventative programs, either due to old age or lack of interest, commitment, or ability; thus, they are an important group to understand and consider.

As rural areas in China face greater challenges in myopia prevention, and are less represented in the current literature, further studies need to be conducted on children’s smartphone usage and parental vision health knowledge in the rural areas of China, which will potentially guide the future preventative initiatives. To address this, we investigated the smartphone usage and parental vision health literacy among primary students of Xingguo, Jiangxi Province as this province is a typical rural county located in the southern part of the Chinese mainland and characterized by a large rural population (80%), and a low level of per capita income and clinical resources^[19]. The results of the survey can provide important information for devising effective myopia prevention strategies in the rural areas of China.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Ethics Committee of the Zhongshan Ophthalmic Center, Sun Yat-sen University, and adhered to the guidelines of the Declaration of Helsinki. The nature and purpose of this research were clearly explained to the participants initially, and informed consents were obtained from all participants online.

Participants This survey investigation was conducted among the parents or guardians of primary school students aged 6 to 12y in Xingguo County, Ganzhou City, Jiangxi Province from July 2020 to August 2020. According to the 2020 data from the Education Bureau of Xingguo County, a total of 55 200 students were enrolled in 30 primary schools (20 in the countryside and 10 in the county town). County town was considered as the region that the county government located in and the countryside was considered to be the rest area of the whole county. The parents were invited to answer a digital questionnaire with the guidance of the teachers who were in-charge of the class units. For parents without smartphones, a printed questionnaire was provided, while for the guardians of left-behind children, an online questionnaire was provided. In a family with more than one child, participants needed to report the familial demographic data and myopia-related knowledge questions once, and then answers regarding each child’s demographic data and vision-threatening behavior were given in the same questionnaire. A consecutive number was generated automatically as an identification after finishing the questionnaire. The teachers in charge of the classes were trained to collect identical numbers and were responsible for clarifying survey related concerns.

Questionnaire This school-based census was conducted through an electronic questionnaire survey. We designed the questionnaire according to the purpose of this survey and the guidance of relevant literature, and it included the ethics approval statement and investigation sections. Demographic factors of the children and their families, the smartphone usage

of children, and parental understanding and attitude towards myopia were evaluated in this survey.

The demographic information included characteristics such as age, sex, grade, school location, and refractive status (based on optometric or vision examination), as well as the parental education level, familial income, and family members that the children live with. The children who lived with neither of their parents were considered to be left-behind children^[18]. The highest educational attainment of two parents were considered to be the parental educational level. Data on children's smartphone usage and daily life style were obtained from their parents on the basis of the following questions: whether they gave permission for smartphone usage to their children, whether and when children had their own phone, and how much mobile screen time did the children have during the weekdays and weekend^[20]. The time for outdoor activities and environmental light intensity when doing homework were also included^[21]. The parental general understanding of myopia was tested with questions on the following topics: consequence of myopia, the effect of outdoor activities on myopic prevention, drugs administered for myopic prevention, the outcome of wearing glasses, proper eye-book and eye-screen distance, and break time. A standard answer was set to each question to quantitatively evaluate the level of parental knowledge on myopia. Furthermore, frequency of vision examination, concern regarding the influence of myopia on children's academic performance, limitation on occupation, and anxiety regarding smartphone usage and myopia progression, were all used to analyze the parental attitude towards myopia and children's smartphone related behaviors. The reliability of this scale has been assessed by internal consistency with the Cronbach's α coefficient was 0.69.

Statistical Analysis Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 25.0 (SPSS Inc., Chicago, IL) program in Windows and the statistical analysis language R (V3.6.3), including the general descriptive analysis, Chi-square test, correlation analysis, and Cox proportional hazards model. The myopic onset was designated as the survival outcome, and the age that the child was clinically diagnosed with myopia was set as the survival time. Statistical significance was set at $P<0.05$. Hazard ratio (HR), and 95% confidence intervals (95%CI) were calculated for risk factors that were independently associated with myopia.

RESULTS

Sample A total of 52 606 parents of students from 30 primary schools provided responses to the questionnaire of the study that was conducted from July 2020 to August 2020, thus resulting in a response rate of 95.3%. The time spent on filling the questionnaire by each respondent was recorded, wherein

those who completed the questionnaire within 90 seconds were considered to be inattentive and their answers were excluded from the result analysis. Among them, 121 answered questionnaires were excluded from the analysis and 52 485 valid answers were received, resulting in an effective response rate of 95.1%.

The average age of the primary students was $10.1\pm 0.98y$; the survey involved a slightly more number of boys than girls (51.2% vs 48.8%). In this survey, 64.3% of the families were from the countryside, while 35.7% were from the county town. Left-behind children accounted for 23.1% of the total sample, with 29.2% in the countryside and 3.2% in the county town. The general prevalence of myopia in the primary students of the Xingguo county was 40.3%, including 36.4% in the countryside and 41.2% in the county town.

Influence of Demographic Factors on the Occurrence of Myopia in Children

Seven factors concerning the Cox regression analysis of the age of myopia onset were included in the questionnaire. As shown in Table 1, the age of myopia occurrence is significantly correlated with several factors, such as, parents' educational level ($P=0.013$), children's sex ($P<0.001$), school location (county town or countryside) ($P<0.001$), children's smartphone ownership ($P<0.001$), and average time spent on the smartphone per day ($P<0.001$).

Our data suggests that girls, students in county schools, and children who owned personal phones and spent more time on them every day were more likely to develop myopia at a younger age. In addition, a higher parental educational level was correlated with a younger age of myopia onset (HR=0.89, $P=0.013$). However, family income ($P=0.305$) and the child being left-behind or not ($P=0.566$) were not significantly associated with myopia onset.

Awareness Rates of Parents to the Adverse Consequences of Myopia

Adverse consequences of myopia can be profound for children's daily life and development. In this survey, three common myopia-induced issues were investigated such as: "Influence of studying", "Limitations for job selections", and "Fundus lesions, even blindness".

On analyzing the responses, we found that the parental awareness regarding the adverse consequences of myopia needed improvement. The awareness rates of "Myopia can cause influence on studying", "Myopia can limit career selections", and "Myopia can cause fundus lesions, even blindness" were 90.7%, 80.0% and 73.1%, respectively (Table 2). For the first issue, the parents' educational level and school location (countryside vs county town) were associated with the awareness rates (countryside, 89.7%; county town, 92.7%, $P<0.01$). Moreover, high-income families possessed greater knowledge on this matter, as compared to that of low-income families (low, 89.6%; high, 93.1%. $P<0.01$). For the

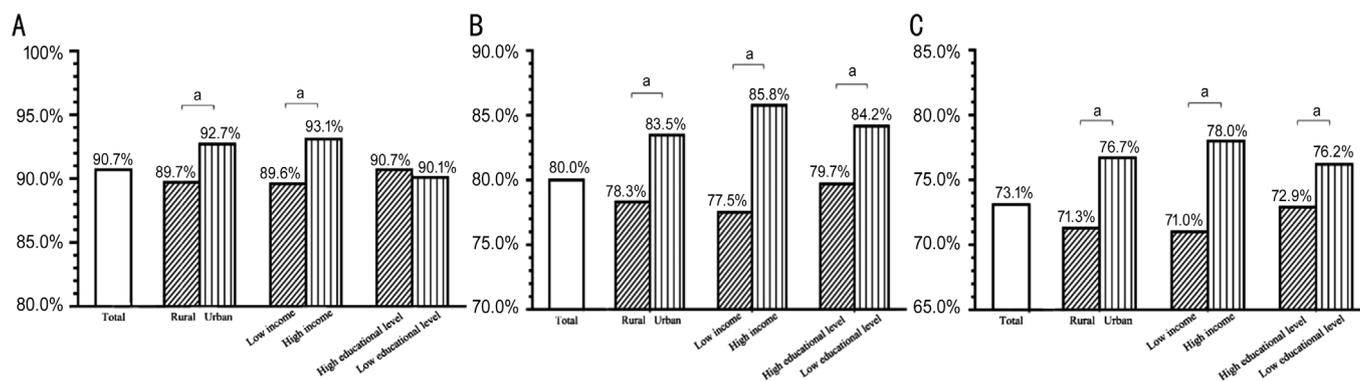


Figure 1 Parental awareness rates of adverse consequences of myopia A: Difficulties of studying; B: Limitations for job selections; C: Fundus lesions, even blindness. ^a*P*<0.01.

Table 1 COX regression analysis of the factors influencing the age of myopia onset in children

Factors	B	SE	HR	95%CI		<i>P</i>
				Lower limit	Upper limit	
Educational levels of parents	-0.11	0.05	0.89	0.82	0.98	0.013
Gender of the child	0.13	0.03	1.14	1.08	1.20	<0.001
Location of the school (county or countryside)	-0.47	0.03	0.62	0.59	0.66	<0.001
The child has his/her own smartphone or not	0.16	0.04	1.18	1.09	1.26	<0.001
Average time spent on smartphone per day	-0.19	0.03	0.83	0.78	0.88	<0.001
Family income	0.03	0.03	1.03	0.97	1.09	0.305
Left-behind child or not	0.02	0.03	1.02	0.96	1.08	0.566

B: Regression coefficient of Cox regression analysis; SE: Standard error of B value; HR: Hazard ratio; 95%CI: Confidence interval.

second and third issues, school location, family income, and parents’ educational level were significantly associated with the parental awareness of the adverse consequences (*P*<0.01; Figure 1). Furthermore, parents living in the county town, those with high income, and parents with high educational levels were more aware of the adverse consequences of myopia. The exact percentages are listed in Table 2.

Awareness Rates of Myopic Preventative Measurements

Preventative measurements play a key role in myopic development. In this survey, the previously reported four measurements were investigated. Overall, the awareness rate of myopic preventative measurements among parents was relatively low and not optimistic. The awareness rate of “Keeping a proper eye-book or eye-screen distance when reading or using smartphones helps prevent myopia (measurement 1)” was the highest, however, the rate was only at 72.5%. Next was “Outdoor activities can prevent myopic incidence and progression (measurement 2)” and “Regular optometric examination and wearing glasses can slow down myopic progression (measurement 3)”, with awareness rates of 67.7% and 34.5%, respectively. “Low-concentration atropine eyedrops can slow down myopic progression (measurement 4)” was the least known by the subjects, with an awareness rate of only 6.9% (Table 2).

In contrast, parents living in the county town, those with high income, and high educational levels were more cognizant of

measurements 1 and 2, as compared to the parents living in the countryside, with low income, and low educational levels (*P*<0.01; Table 2). However, for measurement 3, only the location (county town vs countryside) and family income were significantly associated with parents’ awareness rate (*P*<0.01), whereas educational level did not significantly affect the rate (*P*=0.82). For measurement 4, living in a county and higher parents’ educational level were associated with higher parental awareness (*P*<0.01), although no difference was observed with respect to family income (*P*=0.43).

Incidences of Vision-threatening Behaviors Among Primary Students

Children’s visual habits play a key role in myopic development. As shown in Table 3, the proportion of children with improper habits, including reading in low-light environment and participating in outdoor activities within 1h per day^[21], were noted to be high in the Xingguo County, with incidences of 79.1% and 77.1%, respectively. Although common, “Spending more than 1h on mobile devices on weekdays” and “Spending more than 1h on mobile phones^[20] on weekends and holidays” had relatively lower incidences (15.3% and 24.8%, respectively).

Moreover, demographic factors imposed a strong influence on the incidences of vision-threatening behaviors. First, children from the rural areas and low-income families had increased incidences of the four vision-threatening habits, as compared with those from the country and high-income families

Table 2 The parental awareness rates of the consequences of myopia, myopic prevention measurements and their influential factors

Factors	Total awareness rate	Living region			Family income			Parents' educational level		
		Country-side	County	P	Low	High	P	Low	High	P
Adverse consequences of myopia										
Cause influence of studying	90.7%	89.7%	92.7%	<0.01	89.6%	93.1%	<0.01	90.7%	90.1%	0.16
Limitations for job selection	80.0%	78.3%	83.5%	<0.01	77.5%	85.8%	<0.01	79.7%	84.2%	<0.01
Fundus lesions, even blindness	73.1%	71.3%	76.7%	<0.01	71.0%	78.0%	<0.01	72.9%	76.2%	<0.01
Myopic prevention measurements										
Keeping a proper distance when reading or using smartphones helps prevent myopia	72.5%	69.7%	78.0%	<0.01	70.1%	78.0%	<0.01	72.1%	78.3%	<0.01
Outdoor activities can prevent myopic incidence and progression	67.7%	64.8%	73.3%	<0.01	64.6%	74.5%	<0.01	66.9%	76.9%	<0.01
Regular optometric examination and wearing glasses can slow down myopic progression	34.5%	33.6%	36.3%	<0.01	32.4%	39.4%	<0.01	34.6%	34.4%	0.82
Low-concentration atropine can slow down myopic progression	6.9%	6.4%	7.1%	<0.01	6.8%	7.0%	0.43	6.7%	9.4%	<0.01

Table 3 The incidences of vision threatening behaviors of children

Vision threatening behaviors	P	Reading in low-light environment			Spending > 1h on mobile on weekdays			Spending > 1h on mobile on holidays		
		Outdoor activities < 1h/d	P	P	Spending > 1h on mobile on weekdays	P	Spending > 1h on mobile on holidays	P		
Overall awareness rate										
Residential area										
Countryside	<0.01	79.1%	77.1%	<0.01	15.3%	24.8%	<0.01	<0.01		
County		83.5%	74.8%		16.3%	24.4%				
Income of family		70.9%	81.3%		13.5%	25.5%				
Low	<0.01	81.8%	78.3%	<0.01	15.5%	23.5%	<0.01	<0.01		
High		72.6%	74.3%		14.7%	27.9%				
Parents' educational level										
Low	<0.01	80.3%	77.0%	<0.01	15.5%	24.9%	<0.01	0.33		
High		60.9%	77.9%		12.7%	24.2%				
Students with own smartphone										
Yes	<0.01	75.4%	77.1%	0.98	31.7%	48.2%	<0.01	<0.01		
No		79.5%	77.1%		13.5%	22.3%				
Left-behind children										
Yes	<0.01	85.1%	75.1%	<0.01	18.7%	28.3%	<0.01	<0.01		
No		76.4%	78.0%		13.8%	23.3%				

($P < 0.01$). Conversely, the incidence of “Spending more than 1h on mobile phones on holidays” was similar among students and was not associated with parents’ educational level ($P = 0.33$).

Furthermore, two additional factors were included in this investigation: “Students who owned smartphones, or not,” and “Left-behind children, or not”. Children who had their own smartphones had more incidences of vision-threatening behaviors, including “Reading in a low-light environment”, “Spending more than 1h on mobile devices on weekdays”, and “Spending more than 1h on mobile devices on weekends and holidays” ($P < 0.01$). Specifically, twice as many children who had their own smartphones significantly spent more than one hour of smartphone usage on weekdays (31.7% vs 13.5%) or weekends and holidays (48.2% vs 22.3%, $P < 0.01$). However, children having their own smartphones did not affect the time spent on outdoor activities, with most students participating for less than one hour in outdoor activities (77.1%, $P = 0.98$).

As mentioned earlier, left-behind children comprise a special group in the countryside of China^[22]. Three of the four vision-threatening behaviors significantly occurred more among left-behind children, except for “Outdoor activities <1h/d” ($P < 0.01$). Although most left-behind children spent less than 1h on outdoor activities, the proportion of such children was relatively lower than that of common children (75.1% vs 78.0%, $P < 0.01$).

DISCUSSION

In our study, we investigated the relationship between the demographic factors, parental knowledge regarding the adverse consequences of myopia and myopic prevention measures, and children’s vision-threatening behaviors in the rural county in China. As China is a developing country, most rural areas still face poverty. Xingguo is a typical county located in the middle of China and a total population of 856 700, in which the rural population is 683 100 and accounts for 80% of the total population^[19]. The county’s per capita disposable income in 2018 was 18 041 Yuan (about 2793 USD)^[19], which is relatively low compared with the national average per capita disposable income of 28 228 Yuan (about 4370 USD) in 2018^[23]. Furthermore, a total of 52 606 parents from 30 primary schools provided responses to the in-depth questionnaire in our study. Therefore, we believe that this study might be a good representation of the rural areas in China.

Our results revealed that parents were not well aware of the adverse consequences of myopia, and myopic preventative measures (Table 2). Although the awareness rates of some facts, including “Myopia causes influence in studying” and “Myopia causes limitations for job selection” were acceptable, the most serious adverse consequence of myopia, “Fundus

lesions and even blindness” were only known by 73% of the respondents. Previous surveys reported that more than 50% of children developed high myopia if they were diagnosed before the age of 7^[24]. A 10-year longitudinal study also reported that 35.5% of high myopic patients showed progression to myopic maculopathy^[25]. Thus, “Fundus lesions and even blindness” which are adverse consequences of myopia are quite common. In addition, the awareness rates of parents with respect to myopic prevention and control measures were even lower than in previous studies. Only 67.7% parents were aware of the common measure “Outdoor activities prevent myopic incidence and progression” (Table 3), and 34.5% of the parents knew about the effective myopic preventative approach of “Regular optometric examination and wearing glasses”. However, parents in urban areas obviously had this knowledge^[26]. Moreover, low-concentration atropine eyedrops (0.01%) have been approved in 2017 by the Chinese Consensus Guidelines of Refractive Correction for Children, and only 6.9% of parents in the rural areas were aware of this novel and breakthrough preventive method. Given that a low awareness rate makes it very difficult for children and parents to voluntarily prevent myopia in their daily life, more attention should be given in the improvement of general knowledge concerning myopia among both children and parents.

What causes the lack of parents’ awareness about myopia-related knowledge? According to results in Table 2, although residence (county town vs countryside), family income, and parents’ educational level were significantly associated with the awareness rate of most adverse consequences of myopia and myopic preventative measures, the numerical values were close to that of the overall awareness rate. Therefore, our findings suggest that demographic factors do not play a key role in parental awareness about myopia-related knowledge. The results from the Cox regression analysis also partially support this conclusion, since family income and left-behind child status did not affect the age of myopia onset in children (Table 1). In addition, we suggested that the lack of medical resources and propaganda of basic ophthalmic knowledge in the rural area may partly explain this phenomenon. In comparison to parents in developed areas, those living in rural areas are more inconvenienced to search for professional ophthalmic care due to the unbalanced distribution of medical resources. Although information sharing through word of mouth (e.g., relatives and friends) is one of the most common ways to disseminate medical knowledge^[27], the low awareness rate of novel information limited the dissemination of myopia-related knowledge in our study. Therefore, there is an urgent need for the local public health departments and schools to propagate myopia-related knowledge in rural areas.

Our results showed that demographic factors had a strong influence on the incidences of vision-threatening behaviors, especially “Students who owned smartphones, or not” and “Left-behind children, or not”. Specifically, more than twice as many children who had their own smartphones spend more than one hour on their smartphone every day, as compared to children who do not own smartphones (Table 3). Numerous studies have demonstrated that spending time on a smartphone was significantly associated with myopia onset^[3,8,11]. While the Cox regression analysis revealed that children who had their own smartphones were positively associated with earlier onset of myopia, family income did not affect the age of myopia onset. We speculated the reason to be the regular ophthalmic treatment and stricter supervision on using smartphones by parents of high-income families. Moreover, a previous study supported this hypothesis, wherein a large survey in Taipei city indicated that the household income was positively correlated with the parental mediation of children’s vision-caring behaviors^[28].

Notably, left-behind children might develop serious social problems in the future in both the psychological and physiological aspects as they are often left unattended^[29]. Our data revealed that these children had more vision-threatening behaviors (behaviors 1, 3 and 4), as compared to common children; however, left-behind children indulged in more outdoor activities (behavior 2; Table 3). These findings may partly explain why no significant differences in the age of myopia onset were found between left-behind and common children (Table 1). Left-behind children are prone to establishing wrong visual habits, spending more time on smartphones, and being absent to routine ophthalmic check-ups as per our study. Since they are left unattended and without supervision from their parents, these harmful behaviors are difficult to be addressed by themselves. Furthermore, they face an increasing difficulty in their academics as they grow older, which consequently requires higher visual performance and may break the balance between myopic protective and risk factors. Therefore, we advocate the need for providing more guidance on eye protection in left-behind children from schools and the government.

In conclusion, according to the results of this questionnaire, increased knowledge propagation is needed for the prevention and control of myopia in rural areas. Schools in these areas should teach students and parents about the harms of myopia and its preventive measures. Moreover, local public health departments and schools need to increase visual health literacy of people, especially among left-behind children. We hope that this study will serve as a reference for the creation of myopic prevention policies in the undeveloped areas of China.

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