Emphasizing the Role of Primary Health Care Services in Behavioral Interventions for Childhood Myopia Prevention and Control (Postprint)

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Date: 2023-07-25T00:00:00+00:00

Abstract

Myopia represents the primary factor jeopardizing children's visual health. Standardizing myopia screening initiatives and achieving early detection and early intervention constitute critical measures for preventing and controlling the onset and progression of myopia in children. Currently, myopia screening, the establishment of refractive development records, and their management and application in China remain in their infancy; particularly, the follow-up measures subsequent to refractive record establishment still confront numerous issues and challenges. Based on the current status and characteristics of myopia screening and refractive record establishment in China, and in conjunction with the requirements of tiered diagnosis and treatment, this article conducts an in-depth analysis of the role of primary healthcare services in behavioral interventions for myopia prevention and control in children, aiming to provide recommendations for myopia screening, refractive record establishment, and community-based behavioral interventions in China, thereby better allocating medical resources and enabling their standardized, healthy, and sustainable development.

Full Text

Importance of the Role of Primary Care in Myopia Prevention and Control Behavioral Intervention among Children

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Abstract

Myopia is a major risk factor for vision health in children. Standardizing myopia screening and achieving early detection and intervention are crucial measures for preventing and controlling the occurrence and development of myopia in children. Currently, myopia screening and the establishment, management, and application of refractive development profiles in China are still in their infancy, particularly regarding follow-up measures after profile establishment, which face numerous problems and challenges. Based on the current status and characteristics of myopia screening and post-profile establishment in China, combined with tiered diagnosis and treatment requirements, this paper provides an in-depth analysis of the role of primary care in behavioral intervention for myopia prevention and control in children. We aim to offer recommendations for myopia screening, refractive development profile establishment, and community behavioral interventions in China to better balance medical resources and promote standardized, healthy, and sustainable development.

Keywords: Myopia; Behavioral intervention; Community Health Service Center; Tertiary prevention; Categorized treatment; Public health

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Myopia is a major risk factor for vision health in children [1]. Pathological fundus changes associated with high myopia represent a significant cause of vision impairment and even blindness. Studies have found that in some regions of China, high myopia-related retinopathy has become the leading cause of irreversible blindness in adults [2]. While myopia impacts patients' vision and quality of life, it has also become a global public health concern [3].

In China, myopia generally exhibits trends of high prevalence and earlier onset [4]. Earlier onset age and progressive worsening are important risk factors for children developing high myopia [2]. Researchers have proposed an evidence-based model suggesting that if a 6-year-old child's myopia progression rate could be slowed by 30% under conventional correction and myopia control strategies [5], each diopter reduction in myopia would decrease the lifetime risk of myopic maculopathy by 40% [6]. Therefore, delaying myopia onset and slowing its progression are key to reducing high myopia prevalence and represent the primary goals of myopia prevention and control.

Prevention is considered the best disease control measure [7]. Chinese scholars have proposed a "three-level prevention" strategy for myopia prevention and control in adolescents that emphasizes prevention-first and combined prevention-treatment approaches, advancing the intervention window and improving early diagnosis and control capabilities [8]. In China, community mobilization-based disease control and prevention has a long history. Since the 1950s, China's pub-

lic health achievements—including the eradication of smallpox, polio, malaria, and schistosomiasis—have been realized through strengthened community-level capacity and practice [7]. The National Health Commission has also mandated that primary healthcare institutions provide eye health services for children aged 0–6 [9]. Therefore, integrating tiered diagnosis and treatment requirements with efforts to delegate first- and second-level prevention measures to primary care can fully mobilize grassroots medical personnel, strengthen training, and standardize clinical practice, thereby ensuring effective implementation of myopia prevention and control for Chinese youth.

1. Current Status of Myopia Prevention and Control at Home and Abroad

Singapore was among the first countries to implement adolescent myopia prevention and control. Like China, Singapore has one of the world's highest adolescent myopia rates. Since 2001, Singapore established a national myopia prevention program focusing on vision screening and health education, creating the Singapore Myopia Profile to provide reference data for prevention and control, with notable results [10]. After six years of implementation, myopia prevalence among primary school children decreased by 5%, dropping from 38% in 2004 to 33% in 2009 [11]. School-based outdoor intervention studies have also confirmed that outdoor activity has a protective effect against myopia onset and progression, such as increasing daily outdoor time by two hours or encouraging children to go outside during breaks [12-14]. In the Guangzhou Outdoor Activity Longitudinal Trial (GOAL), adding 40 minutes of outdoor time after school reduced myopia incidence by 23% over three years compared to control schools [15].

China's "Anyang Childhood Eye Study" constructed a government-hospital-school tripartite integrated myopia prevention and control platform model, achieving favorable results in reducing myopia prevalence among children. Between 2011 and 2018, myopia prevalence among primary and secondary school students decreased by 17.90% [16]. While regional implementation measures vary, all emphasize the importance of behavioral intervention. Singapore implemented a community-based outdoor intervention program showing that over six months, the intervention group (14.75 hours/week) had significantly increased weekly outdoor time compared to the control group (12.40 hours/week) (P=0.04). However, after nine months, the between-group difference in outdoor time was no longer significant (intervention group 15.95 hours/week vs. control group 14.34 hours/week, P=0.29) [17], and myopia rates did not change significantly in either group [18].

China's "Anyang Childhood Eye Study" also demonstrated through a randomized controlled trial that text message reminders to parents to take children outdoors more frequently could reduce myopia incidence by 18.8% over three years, with more pronounced effects in non-myopic children. Common clinical interventions such as spectacles (155–303 RMB/year), low-concentration atropine

(3,000 RMB/year), and orthokeratology lenses (20,000 RMB/year) are costly, whereas incorporating health education into school vision screening programs costs only 2.89–3.03 RMB per person annually, with behavioral intervention costing merely 386–568 RMB per person annually [1]. Importantly, assuming age 15 as the endpoint for myopia progression, text message-based behavioral intervention can reduce axial length by approximately 0.5 mm, decrease myopia by 1.2 diopters, and lower myopia prevalence by about 11.7%. This provides robust primary-level evidence for current myopia prevention and control policies for Chinese children and adolescents, confirming that behavioral intervention is the most cost-effective approach [13].

2. Problems Faced in Myopia Prevention and Control for Chinese Children

China has comprehensively strengthened its national monitoring network for children and adolescents' vision health and related risk factors, along with data collection and information system development [20]. Implementing personalized, targeted prevention and control programs requires critical attention to timely re-examination and intervention for those with abnormal screening results. A continuous three-year study of 660 individuals found that through establishing vision screening warning levels and implementing corresponding interventions, 24.5% of individuals with uncorrected distant visual acuity $ $4.90 and SE<0.00 D (Level 1) recovered to Level 0 (uncorrected distant visual acuity $ $4.90); 37.5% of those with uncorrected distant visual acuity <4.90, 0.00 D ≤ SE<2.00 D, and cylindrical absolute value <1.50 D (Level 2) recovered to Level 0; and 2.0% of those with SE $ $2.00 D or SE<0.00 D or cylindrical absolute value >1.50 D (Level 3) recovered to Level 0 [4]. This population will be the focus of clinical intervention.

Model predictions indicate that myopia intervention effectiveness must reach 70% or higher [21] to achieve the target of reducing the overall myopia rate among children and adolescents nationwide by more than 0.5 percentage points annually before 2030, with a significant decrease in new myopia cases [20]. How can we intervene effectively? China implements a "multi-pronged approach" to practice this nationwide "behavioral intervention" action [20], vigorously promoting the "double reduction policy," exam reform, and strengthened outdoor physical exercise. The Myopia Management White Paper (2022) clearly states that scientific, personalized myopia management plans must be provided to children and adolescents based on individual conditions [22]. The "Screening Standards for Refractive Errors in Primary and Secondary School Students" also provides specific implementation measures, recommending at least two annual examinations of uncorrected distant visual acuity and non-cycloplegic computer refraction [23].

A major current challenge is the follow-up re-examination of individuals with abnormal screening results. China lacks public refractive clinics, and optometry and spectacles fitting are not covered by medical insurance, leading most

people to choose optical shops. However, the professional competence of optical shop staff varies considerably. Liang et al. [24] investigated the professional standards of optical shops and found that for children's first optometry, 41.73% used conventional refraction while 58.27% used medical refraction; only 3.15% performed cycloplegic refraction before optometry, 24.41% used fogging methods, and 72.44% used direct refraction. Regarding whether cycloplegic refraction is necessary for children's first optometry, only 4 out of 127 optical shops explicitly considered it necessary. Survey results on the age range for cycloplegic refraction showed that 52.76% did not know the specific age range, 5.51% believed it should be before age 6, 25.98% before age 12, 7.09% before age 18, and 8.66% believed it was only needed for children with amblyopia or hyperopia. Studies indicate that undercorrection or non-correction contributes to myopia onset and progression [25-27]. Therefore, there is an urgent need to standardize the follow-up process for children with abnormal vision, guide schools and parents to understand the importance of mydriatic refraction, and correct misconceptions about spectacles fitting to fully realize the role of vision screening and achieve early detection and intervention. This work requires the assistance of numerous grassroots health workers, particularly community health service center staff.

3. Practice and Exploration of Primary Healthcare Institutions in Behavioral Intervention for Myopia Prevention and Control

The National Health Commission's "Service Standards for Eye Health and Vision Examination for Children Aged 0–6 (Trial)" clarifies that primary healthcare institutions such as township health centers, community health service centers, and county-level maternal and child health institutions should provide eye health services for children aged 0–6. By July 2021, China had established 34,943 township health centers in 29,600 townships and 10,122 community health centers in 8,925 streets [28], essentially achieving full coverage. Community health workers play a vital role in providing primary healthcare and serve as the foundation and core of the health system. Child preventive care is one of the main tasks of China's community health service centers, allowing them to reach children and adolescents in their daily lives, facilitate behavioral intervention measures in myopia prevention and control, and serve as the key to ensuring implementation of child eye health and vision examination work [29].

Some community health centers in Shanghai have preliminarily established a "four-in-one" management model centered on children and adolescents, with families as units, communities as scopes, and continuous whole-process services to improve vision conditions among youth [30]. Hefei, Anhui, has established a "myopia prevention and control" specialty eye clinic through a "university-primary healthcare institution" partnership model, forming a vertically integrated tiered eye care system that leverages internet big data platforms and university optometry expertise to manage myopia in grassroots children and adolescents [29]. Some pilot community health centers in Beijing have leveraged community medical advantages based on vision screening to initially establish

a vision screening warning mechanism [4], focusing on promoting three-level prevention of myopia in school-age children into campuses. By uniting families, schools, and medical institutions and establishing warning levels, they have proposed corresponding intervention plans with positive results. According to the "Screening Standards for Refractive Errors in Primary and Secondary School Students," screening results are divided into four warning levels with corresponding intervention plans. Through science popularization and campus lectures, they have raised awareness of myopia hazards among children and parents, corrected parental misconceptions, and improved awareness and feedback rates regarding vision screening. Building on existing medical alliances and utilizing opportunities for "specialty department construction in community health service institutions," they have established "two-way referral green channels" as "incubation bases and construction bases" with tertiary hospitals within their jurisdictions. Specialists participate in re-examinations for abnormal screening cases, and referrals to higher-level hospitals are made through green channels for orthokeratology and progressive multifocal lens fitting. Compared with September 2019, myopia incidence rates across all age groups in designated pilot schools decreased significantly by September 2022: from 54% to 37% among 11-year-olds, 37% to 34% among 10-year-olds, 29% to 27% among 9-year-olds, 15% to 14% among 8-year-olds, and 17% to 7% among 7-year-olds. This implementation improved re-examination rates for children with abnormal vision screening, strengthened professional training for grassroots ophthalmic personnel, and facilitated public access to medical care, making it replicable within certain scopes. Practice has confirmed that community health service centers can serve as an important link in China's myopia prevention and control efforts, supplementing tertiary hospitals, universities, and research institutions. With strong research and medical resource support, they can fully leverage their advantages of convenience and accessibility. Guided by the tiered diagnosis and treatment model of "primary care first, two-way referral, acute-chronic separation, and vertical collaboration," medical alliances can be formed to promote regional medical resource sharing and vertical flow, improving the tiered diagnosis and treatment service system [31] and jointly advancing the healthy development of myopia prevention and control for Chinese youth.

4. Importance and Feasibility of Primary Healthcare Institutions in Behavioral Intervention for Myopia Prevention and Control

In China, community mobilization-based disease control and prevention has a long history. Since the 1950s, China's public health achievements—including the eradication of smallpox, polio, malaria, and schistosomiasis—have been realized through strengthened community-level capacity and practice. Community-level public health practice in China, established in 1999, supports health promotion and public understanding of science, guiding active public participation in disease control and prevention, with grassroots public health practitioners playing a crucial role [7]. The "three-level prevention" strategy for adolescent myopia also prioritizes prevention. As the "foundation" of myopia prevention and control,

myopia screening and refractive development profile establishment and management remain in initial stages [32], facing many problems and challenges. Current efforts primarily rely on "point" radiation from tertiary hospitals, research institutions, and social resources, with limited coverage and issues such as information redundancy, duplication, and lack of sharing, which greatly diminish the effectiveness of screening and profile establishment. Effective supervision mechanisms should be established to integrate screening resources, leverage points to cover broader areas, and achieve "medical institution-controllable information sharing" of screening resources regionally or even nationally. This would make electronic profiles "portable" and "dynamic," enabling timely updates and real-time transfers to truly fulfill their intended role and ensure sustainable myopia prevention and control. The "Healthy China Action (2019–2030)" also encourages cooperation between community clinics and county-level CDCs for non-communicable disease management and participation of private sector organizations and NGOs in community-level healthcare reform [20].

Drawing on China's experience with "child systematic management" can make electronic profiles "dynamic." Since 2009, China has included health management for children under three years old in its basic public health service projects [33], using child systematic management rates as important evaluation indicators [34]. Over ten years, the management rate for children under three has shown an upward trend, reaching 91.9% in 2019—an increase of 12.8% compared to 2010 [34], essentially forming integrated, comprehensive, and continuous health management that achieves systematic management goals [34].

The first level of the three-level prevention strategy for adolescent myopia primarily aims to "prevent myopia onset," targeting kindergarten and lower primary school grades with regular monitoring of hyperopia reserve [35] to protect this reserve and reduce myopia incidence [36]. The second level aims to "control myopia progression," focusing on primary and secondary school students with school-based behavioral intervention as the main approach, supplemented by family and hospital interventions. The third level targets "complication prevention and control" to reduce disability and blindness from high myopia complications, focusing on high school and college students. The key lies in intervention; refractive profile establishment is merely a means to evaluate intervention effectiveness and serve clinical intervention. Profiles without intervention amount to "armchair strategy." In China's healthcare system, community hospitals and community health care are extremely important components. With their extensive and comprehensive characteristics as the most basic health security institutions, they should play a more important role in myopia prevention and control. Establishing a school-assignment system for primary healthcare institutions [20] can delegate first- and second-level prevention and behavioral interventions to community and grassroots hospitals, managing myopia progression through child health management models.

However, primary healthcare institutions still face a series of challenges. First, the talent shortage at grassroots hospitals cannot be ignored. Although studies

show that community health technical personnel in China have grown steadily in recent years, the growth has been slow and cannot meet increasing medical demands [37], especially the severe shortage of specialists. Therefore, it is essential to cultivate excellent vision health professionals, strengthen training for grassroots ophthalmic personnel, emphasize technical and personnel support for ophthalmology, establish dedicated child eye health service departments, increase medical staff numbers, and enhance professional quality. Improving community medical institutions' capabilities can also enhance community residents' confidence and increase their willingness to seek community care [38]. Additionally, capabilities for vision screening, common eye disease diagnosis and treatment, and emergency management should be improved [20] to ensure screening results are readable, interpretable, and actionable, enhancing the timeliness and effectiveness of myopia screening feedback. "Two-way referral" green channels should be established with strengthened referral systems to attract more parents to bring children to community institutions through procedures, resource allocation, and reimbursement measures, achieving personnel diversion and tiered management.

Second, hardware facilities are relatively inadequate, particularly for specialty construction. Youth eye health monitoring should include vision, refractive status, and axial length as regular indicators, along with fundus, intraocular pressure, and ocular surface health [22], requiring government funding and equipment investment in grassroots hospitals, especially community health centers, to increase necessary ophthalmic medical facilities. As integration points for two systems, community health institutions should introduce child eye health programs based on existing child health care, regular physical examinations, and child care programs, with adequate funding ensuring good development of these programs.

5. Problems and Prospects

We are pleased to see that some community health centers have recognized the importance of child myopia prevention and control, attempting to manage this common childhood disease using chronic disease management approaches. They have introduced optometry professionals and gradually explored suitable eye health management models through cooperation with higher-level hospitals. However, we must recognize that adolescent myopia prevention and control cannot achieve results in a short time—it is a protracted and persistent battle. China has already taken the first step through vision screening and refractive profile establishment to understand the baseline situation. The "Anyang Childhood Eye Study" has established reference ranges for hyperopia reserve and axial length across age groups for Chinese school-age children using data from non-myopic children in natural population cohorts, providing important reference bases for establishing refractive development profiles and adolescent myopia prevention and control [34]. Simultaneously, standardized intervention processes for abnormal screening cases should be implemented to ensure timely

and effective information feedback. By fully leveraging community health service centers' rich experience in child health management, introducing child eye health management, training community professionals, promoting community practice standardization and specialization, facilitating "two-way referral" and strengthening referral systems, personnel diversion and tiered management can be achieved. In summary, achieving the two-stage overall goals outlined in the "Plan" [20] requires joint efforts from government, medical institutions, families, schools, and students, with comprehensive prevention and control measures from the whole society to jointly protect children's eyes [39].

Author Contributions: WANG Jie was responsible for data collection, analysis, interpretation, and manuscript writing. LI Shiming and WEI Shifei were responsible for quality control and manuscript review. WANG Ningli was responsible for conceptualization, design, and overall supervision.

Conflict of Interest: The authors declare no conflict of interest.

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(Received: March 20, 2023; Revised: May 20, 2023)
(Editor: ZHAO Yuecui)

Note: Figure translations are in progress. See original paper for figures.