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Myopia in Chinese Adolescents: Socioeconomic Impacts from the Perspective of Stakeholders

SUN Zhengji

Doctor of Management

Supervisor:
PhD Dália Nogueira,
ISCTE University Institute of Lisbon

November, 2024

BUSINESS
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Abstract

Myopia, a prevalent ophthalmic issue causing vision impairment and heightened ocular disease risks, especially among adolescents, poses significant societal, individual, and familial impacts, along with escalating socio-economic burdens.

Using stakeholder theory, this study defines quantitative indicators for stakeholders related to adolescent myopia. Focusing on Dalian's myopic adolescents, data is gathered via fieldwork and public reports, employing Granger causality tests and regression analysis to assess socio-economic impacts.

The results show that the number of adolescents with myopia has a positive effect on the investment of medical resources in hospitals and the material investment for myopia prevention and control in schools (lag period=1, $p<0.05$), as well as to the government's health policies and visual health investment (lag period=1, $p<0.05$; lag period=2, $p<0.01$). Years of myopia have a significant negative effect on academic achievement, quality of life and mental health. Degree of myopia has a significant negative effect on mental health, and a significant positive effect on lens fitting costs.

This study enriches the research gap of stakeholder theory in adolescent myopia, and establishes the theoretical links between the number of adolescents with myopia, the years of myopia, the degree of myopia and each stakeholder. The results can not only provide management support for adolescents to cope with the negative effects of myopia at the individual and family levels, but also help to provide a decision-making basis for government departments to formulate policies related to adolescent myopia.

Keywords: Adolescent myopia, Socioeconomic impact, Stakeholders

JEL: A23; M1

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Resumo

A miopia é um problema oftalmológico de elevada prevalência que causa défices visuais e aumenta os riscos de doenças oculares, especialmente nos adolescentes. A doença tem um impacto importante anível social, individual e familiar assim como importante impacto socioeconómico.

Com base na teoria dos stakeholders, este estudo tem como objetivo definir indicadores quantitativos (para os stakeholders) relacionados com a miopia em adolescentes. Utilizando como população-alvo os adolescentes míopes em Dalian, os dados foram recolhidos através de trabalho de campo e da análise de relatórios públicos. Foram utilizados os testes de causalidade de Granger e análise de regressão para avaliar o impacto socioeconómico da doença.

Os resultados revelam que o número de adolescentes com miopia tem um efeito positivo no investimento em recursos clínicos dos hospitais, no investimento em recursos para a prevenção e controlo da miopia nas escolas (período de defasagem = 1, $p < 0,05$), nas políticas de saúde do governo e no investimento em saúde visual (período de defasagem = 1, $p < 0,05$; período de defasagem = 2, $p < 0,01$). Os anos de miopia têm um efeito negativo significativo no desempenho académico, na qualidade de vida e na saúde mental. O grau de miopia apresenta um efeito negativo significativo na saúde mental e um efeito positivo significativo nos custos de adaptação de lentes.

Este estudo foca-se na aplicação da teoria dos stakeholders à miopia em adolescentes estabelecendo ligações teóricas entre o número de adolescentes com miopia, os anos de miopia, o grau de miopia e cada stakeholder. Os resultados fornecem suporte para a gestão dos efeitos negativos da miopia ao nível individual e familiar e contribuem para a tomada de decisões por parte dos departamentos governamentais na formulação de políticas relacionadas com a miopia nos adolescentes.

Palavras-chave: Miopia na adolescência, Impacto socioeconómico, Partes interessadas
JEL: A23; M1

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摘　要

近视是世界上最常见的眼科疾病之一，会导致视力下降、眼部疾病风险激增，尤其是近年来青少年近视发病率攀升对社会、个人及其家庭的影响日益凸显，带来的社会经济负担持续增加。

本研究基于利益相关者理论，厘清了青少年近视相关利益主体定量测度指标；以大连市近视青少年为研究对象，通过实地调研、公开报告等收集数据，应用格兰杰因果检验、回归分析等方法，实证分析青少年近视的社会经济影响。

结果表明，青少年近视人数对医院医疗资源投入、学校近视防控物资投入有显著促进作用（滞后期lp=1，p<0.05），对政府卫生政策和视觉健康投入有显著促进作用（滞后期lp=1，p<0.05；滞后期lp=2，p<0.01）。近视年限对学业水平、生活质量、心理健康等有显著负向影响；近视程度对心理健康有显著负向影响，对配镜费用有显著正向影响。

本研究丰富了利益相关者理论在青少年近视中的研究空白，建立了青少年近视人数、近视年限及近视程度与各利益主体的理论联系。研究结果不但能够为青少年个人及家庭层面应对近视负面影响提供管理支持，而且有助于为政府部门制定青少年近视相关政策提供决策依据。

关键词：青少年近视，社会经济影响，利益相关者

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Acknowledgements

This is the end of the line, the pen for the end, the heart of a thousand thoughts, a thousand feelings. Looking back on this journey of learning, the end is in sight, along the way both the joy of harvest, but also the sigh of regret; both unremitting perseverance, but also occasional slack; both the admiration of knowledge, but also the deep feeling of friendship. At this moment, when I am about to wave goodbye to this stage, my heart is overflowing with endless gratitude to all the people who accompanied and supported me along the way.

I would like to extend my most sincere thanks to my tutor. Fortunately, I met such a teacher, Professor Dália Nogueira, on my way to school. With the light of wisdom, the tutor lit up the road of my academic exploration; With careful guidance, it helped me overcome many difficulties in my academic journey; With profound feedback, I was inspired by my endless thirst for knowledge. In the process of writing my thesis, no matter how much challenge I encounter, my tutor always gives me patient guidance and wise advice and encouragement, which not only teaches me how to think and solve problems, but also helps me understand how to persevere and pursue Excellence in my studies and life. Teaching rigorous and humble life attitude and academic attitude is the direction I have been working hard for.

Also, I would like to thank my family members. They respect every choice I make, give unconditionally and without expecting anything in return, their understanding and tolerance have given me the greatest support so that I can pursue my academic dreams without any distractions. It has become my motivation to keep moving forward. No matter when, the love of my family is my most solid support and the softest harbour in my heart.

I would also like to thank the friends around me. Along the way, my friends have always been with me, no matter rain or shine, no matter how rough it is. When I need to lend a helping hand in time. We all work hard in our respective fields, we share our thoughts, talk about our feelings, keep each other company, and we encourage each other to move forward. In the long years to come, may we continue to maintain this precious friendship, walk together, and meet again in higher and farther places.

This study time not only let me harvest the fruit of knowledge, but also let me understand the true meaning of life. It makes me believe more firmly that life should have different splendors and choices; it makes me learn to always keep love and be curious about the world;

it makes me know how to always keep an upward posture and keep pursuing higher goals; and it makes me have the courage to always keep vitality and not to be afraid of the passing of the years. I believe I will keep moving forward on the road of life in the future and meet a better self.

致　谢

行文至此，落笔为终，心中思绪万千，感慨万千。回望这段求学之旅，终点已在眼前，沿途既有收获的喜悦，也有遗憾的叹息；既有不懈的坚持，也有偶有的懈怠；既有对知识的仰慕，也有对情谊的深深感动。此刻，当我即将与这一阶段挥手告别，心中满溢的，是对所有陪伴、支持我一路走来之人的无尽感激。

我要向我的导师致以最诚挚的谢意。很幸运，求学之路上我遇到了一位这样的师者Dália Nogueira教授。导师以智慧之光，照亮了我学术探索的道路；以悉心指导，助我跨越了学术旅途中的重重难关；以深刻的反馈，激发了我对知识的无尽渴望。在论文撰写的过程中，无论我遇到多大的挑战，导师总是耐心指导，给予我明智的建议和鼓励，不仅教会了我如何思考和解决问题，更让我懂得了如何在学术和人生中坚持不懈、追求卓越。教授严谨谦逊的人生态度和学术态度是我一直努力的方向。

同时，也要感谢我的家人们。他们尊重我的每一个选择，无条件的付出与不求回报，在我追求学业梦想的过程中，他们的理解与包容给了我最大的支持，成为了我不断前进的动力。无论何时，家人的爱是我最坚实的后盾，也是我心中最柔软的港湾。

路遇良友，还要感谢身边的朋友们。一路走来，朋友始终陪伴在我的左右，无论风雨、无论坎坷。在我需要时及时伸出援手。大家在各自的领域努力奋斗，我们一起分享心境、倾诉感受、彼此陪伴，我们互相鼓励前行。在未来漫长的岁月里，愿我们继续保持这份珍贵的友谊，相伴而行，在更高更远处重逢。

这段学习时光，不仅让我收获了知识的果实，更让我明白了人生的真谛。它让我更加坚定地相信，人生应该拥有不一样的精彩与选择；它让我学会了永远保持热爱，对这个世界充满好奇；它让我懂得了永远保持向上的姿态，不断追求更高的目标；它让我拥有了永远保持活力的勇气，不畏惧岁月的流逝。相信我会在未来的人生之路上不断前行，遇到更好的自己。

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Chapter 1: Introduction

1.1 General setting

Myopia is the condition that when the eyes are in a relaxed state, external parallel light rays are refracted by the refractive system of the eye and focused in front of the retina in advance, instead of right on the retina, so that the retina cannot give a clear image (D. F. Wang, 2021). Myopia has become one of the most prevalent ophthalmic diseases in the world, affecting around 1/3 of the world population (Hansen et al., 2021). This visual disorder increasingly prevalent in modern society, is threatening the vision health of millions of people in the world, not only affecting their daily life, but also leading to a range of symptoms, such as visual fatigue, exotropia or changes in eyeball morphology (Greene & Greene, 2018). More seriously, myopia with the high morbidity may also cause a series complicated ophthalmic conditions, e.g. cataract, glaucoma and retinal detachment (Theophanous et al., 2018). Treatment of such diseases is expensive and requires long-term rehabilitation and care, which undoubtedly brings a heavy burden to individuals and the society. According to the statistics of the World Health Organization, ametropia dominated by myopia may rank the 8th disease with the highest economic burden in the world in 2030, and the economic burden brought by the rising incidence of myopia will continue to increase.

As a populous country, China has a higher prevalence of myopia, and the population with myopia reaches approximately 700 million, with the proportion far higher than that in the United States and other developed countries (J. Wang et al., 2023). Especially in recent years, with the rapid development of science and technology, cell phones, tablet computers and other electronic products have penetrated into people's lives in various aspects. Electronic products are widely used in classroom teaching, providing students with more abundant and diverse learning resources, but also greatly increasing the burden of students in using eyes. Long time staring at the screen can accelerate the development of myopia, in addition to eye fatigue. According to the results of a national random checking on adolescent myopia issued by China Ministry of Education in August 2020, after the COVID-19 epidemic, the national myopia rate increased by 11.7%; and in 2022, the overall myopia rate of children and adolescents nationwide was 51.9%. China leads the world in terms of the prevalence of myopia among

children and adolescents, featuring the "high incidence, deep degree, and younger age" (F. Yang et al., 2024). The problem of adolescent myopia has gradually evolved into a social and economic challenge that cannot be ignored, not only affecting the quality of life of individuals, but also causing heavy economic burden to the whole society. From the individual perspective, adolescent myopia will cause various medical expenses, such as optometry, purchase of spectacle glasses or contact lenses, and more complicated ophthalmic surgeries. The related expenses of optometry and lens fitting in China have exceeded RMB100 billion each year, and the expenses of myopia laser surgery have exceeded RMB10 billion each year (Z. H. Xu et al., 2024). Adolescent myopia may also affect the mental health and learning of adolescents. For example, it may lead to an increase in the anxiety, affect their mental health and cause negative impact on their academic performance. From the social perspective, the aggravation of adolescent myopia will force hospitals to increase the corresponding medical resources; schools to increase the investment on desks, lamps and other materials; relevant social organizations to increase the publicity of myopia prevention and control, and the governments to tilt health policies toward this problem, thus increasing the economic burden of the whole society.

Given that the socioeconomic impacts of adolescent myopia may involve multiple stakeholders, including adolescents themselves, their families, schools, medical institutions, government departments and various social organizations, this study, from the perspective of stakeholders, explores the internal relationship between adolescent myopia and stakeholders, and then clarifies the social and economic impact of adolescent myopia. This study can provide effective prevention and control measures and suggestions for myopic adolescents and their families, to help them better cope with the challenges brought by myopia. It can also provide theoretical support and decision-making basis for government authorities and related organizations in formulating relevant policies and improving relevant systems.

1.2 Objectives

The objectives of the study mainly cover the following three aspects:

(1) Identify the stakeholders involved in adolescent myopia based on the stakeholder theory. Adolescent myopia will involve many stakeholders, such as adolescents themselves, their families, schools, hospitals, governments and social organizations. In order to comprehensively analyze the socio-economic impact of adolescent myopia, we will first identify the stakeholders from the perspective of stakeholders, to lay the foundation for the follow-up studies.

(2) Determine the variable measurement indicators of all stakeholders. On the basis of

defining the stakeholders, we will analyze the measurement indicators of each subject: the indicators related to hospitals, including the investment on medical resources, such as the cost of medical equipment and medical staff; the indicators related government, including government health policy and visual health investment; the indicators related to social organizations, including publicity and education investment in prevention and control; the indicators related to families, including medical expenses and lens fitting expenses; the indicators related to adolescents, including their academic performance, mental health and quality of life; and the indicators related to the school, including material input.

(3) Build the theoretical model, analyze the relationship between adolescent myopia and stakeholders, and explore the socioeconomic impact of the disease. After the measurement indicators of various stakeholders are determined, the theoretical model is further constructed, the internal relationship between variables is identified through Granger causality test and regression analysis, and the socioeconomic impact of adolescent myopia is analyzed.

1.3 Research question and research dilemma

1.3.1 Research question

According to the subject of the present study, research questions are as follows:

(1) What are the socioeconomic impacts of myopia in adolescents from a stakeholder perspective?

(2) How to deal with the negative socioeconomic impact of myopia in adolescents?

The socioeconomic impact of myopia in adolescents may involve multiple stakeholders. In order to answer the above two questions more deeply and accurately, it is necessary to carry out specific and quantitative research.

1.3.2 Research dilemma

There exist study difficulties in the following two aspects in the present study:

(1) It is difficult to determine the measurement indicators of various stakeholders. Relative to serious public health crisis of adolescent myopia, public health management research is lacking in China. Besides, the public lacks eye health knowledge about adolescent, and health and wellness policies provide weak protection for eye health in adolescents. The existing studies mainly include public health and medical studies focusing on the development mechanism and risk factors of adolescent myopia, and health economic studies exploring the economic burden

from eye diseases, causing it difficult to determine the measurement indicators of stakeholders in the study.

(2) It is difficult to obtain the data of each variable measurement indicator. Some data of the variable measurement indicators for the study were found missing and non-existent in the process of data collection and collation, requiring to calculate the indicator data with the existing calculation methods to fill in the gaps. This process needs a lot of manpower, which is one of the difficulties encountered in the study.

1.4 Outline of thesis

This paper studies the social and economic impact of myopia in adolescents from the perspective of stakeholders. This paper is divided into seven parts.

The first chapter is the introduction. This paper mainly introduces the research background, research purpose, research dilemma, research problems and thesis outline.

The second chapter is the literature review. This part mainly discusses the stakeholder theory, the influence of adolescent myopia and the main research results and research progress of its stakeholders, and provides theoretical support for the follow-up research of this paper.

The third chapter is the theoretical framework. First of all, in view of the shortcomings of existing studies, based on the stakeholder theory and focusing on the social and economic impact of myopia in Chinese adolescents, this paper proposes the research hypothesis and model construction, clarifies the sources of research data, and expounds the design of variables, measurement methods and sources.

The fourth chapter is the methodology. Firstly, Granger causality test was used to study the influence of myopia on teenagers in society. Then, Chi-square test and ordered logistic regression were used to study the effects of myopia on adolescents at family and individual levels.

The fifth chapter is the result. Combined with quantitative research, the conclusion of empirical research is summarized and elaborated.

The sixth chapter is the discussion. Combined with the research results, it provides decision-making basis for hospitals, governments and other stakeholders to formulate accurate management policies.

The seventh chapter is the conclusion and prospect. Summarize the research conclusions, and discuss and look forward to the shortcomings of this paper.

The research pathway for this thesis is shown in Figure 1.1.

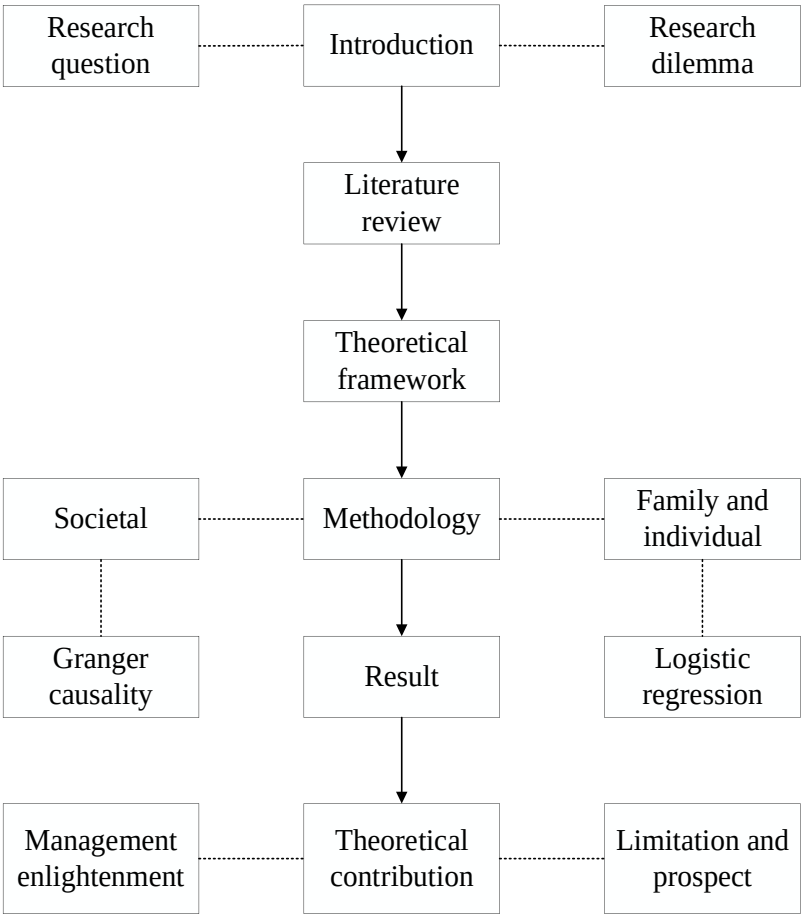

Figure 1.1 Research pathway

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Chapter 2: Literature Review

2.1 Research progress on socioeconomic impacts of myopia in adolescents

2.1.1 Study on myopia in adolescents

China has the highest prevalence of myopia in the world, and the number of myopia shows a trend of "the overall base is getting bigger and bigger, and the initial patients are getting younger and younger" (Z. M. Fan & Liu, 2018). The prevalence of myopia in adolescents is higher, and shows a yearly growing trend (Wei, 2019). In 2012, about 437 to 487 million people were myopic in China, with the prevalence of 35.16%-39.21%, among which the prevalence of myopia was 46.64% in people aged 6 to 15 years and 54.5%-79% in people aged 16 to 24 years, respectively (L. Li, 2016). In 2014, the prevalence of myopia in China was 45.71% in primary school students, 74.36% in junior high school students, and 83.28% in senior high school students, respectively (Bai et al., 2013). In 2018, the overall prevalence of myopia in children and adolescents in China reached 53.6%; the prevalence of myopia in primary school students, junior high school students, and senior high school students were 74.36%, 83.28%, and 86.36%, respectively (X. X. Zhao, 2023).

Most scientific research tends to classify more than 60% myopia as early-onset myopia, which is also often called juvenile myopia in the medical field. The characteristic of this type of myopia is that its onset period is mainly concentrated between the ages of 9 and 11, which is just the key period for children to transition to teenagers. Since then, myopia often continues to deepen and develop in the early stage of the whole teenager, which has a long-term impact on patients' visual health (Gilmartin, 2004). Preventing myopia is one of the important ways to reduce the prevalence of myopia and protect visual health. By taking scientific and effective preventive measures, we can not only significantly reduce the proportion of myopia in the new population, but also slow down the progress of the disease for individuals who are already nearsighted, thus comprehensively improving the public's eye health level (Y. Zou, 2020).

But at present, the exact cause of myopia has not been fully clarified. It is generally believed that the occurrence and development of myopia is caused by the complex process of genetic and environmental factors working together and influencing each other. Genetic factors play an important role in the formation of myopia. If parents have myopia, the risk of their children

suffering from myopia may increase accordingly. At the same time, environmental factors cannot be ignored. Long-term close eye use, lack of outdoor activities and poor lighting conditions are all considered to be important external factors that promote the development of myopia. These two factors are intertwined and jointly affect the individual's visual health (Althnayan et al., 2023). Because myopia has irreversible physiological characteristics (Myrowitz, 2012), once formed, it may often accompany the patient's life. If it is not controlled and managed in time and effectively, the situation of low myopia may gradually deteriorate and further develop into high myopia, which will not only lead to a serious decline in vision, but also lead to a series of eye complications, which will cause obvious damage to patients' visual function, cause greater restrictions on patients' life, further limit their choices and possibilities in colorful life, and seriously affect their quality of life and happiness (Y. F. Yang, 2018). High myopia is the main cause of macular degeneration, which leads to visual impairment and even blindness (Varosanec et al., 2024). The probability of secondary rhegmatogenous retinal detachment in high myopia is significantly higher than that in healthy people, which seriously affects the vision of patients (Ip et al., 2007). Compared with the normal population, the density of cataract lens nucleus is higher in patients with high myopia, and the probability of nuclear cataract is increased (Hornbeak & Young, 2009).

Genetic factors play a vital role in the process of myopia. The occurrence and development of myopia is closely related to the individual's genetic background. Family genetic history is an important index to evaluate the risk of myopia. If a person's parents or immediate family members have myopia patients, then the probability of suffering from myopia is relatively high (X. Tian et al., 2018). According to other domestic and foreign genetic data, with the increase in the number of myopic parents, the prevalence of the disease in children increased from 7.6% and 14.9% to 43.6% (B. L. Wen et al., 2017). With the identification of multiple genetic loci, myopia has been assessed as a common complex disease (Hornbeak & Young, 2009). This shows that the heritability of myopia has been confirmed (Wojciechowski, 2011). Scholars in the field of gene research have summed up an important point when discussing the influence of genes on the formation and development of myopia: "Although genetic factors do play an important role in the etiology of myopia and show a certain degree of moderate influence, there are still many key factors and mechanisms that cannot be fully explained and covered by gene theory alone." Therefore, environmental factors play a role far beyond the comprehensive influence of a few gene variations or genetic tendencies (Jacobi & Pusch, 2010).

As a key component of many environmental factors affecting vision health, regional factors' complexity and diversity can explain the difference of myopia incidence in different regions.

The incidence of myopia in urban areas of China is generally higher than that in rural areas, which can be explained to a great extent by regional factors (W. Cai et al., 2024). For example, the prevalence of myopia in 12-year-old children was 70.9% in Beijing (Y. Guo et al., 2017), whereas the prevalence in children at the same age was relatively lower at the same period in rural areas in China, the prevalence in county of Motuo, Xizang was 15.00% (Y. Cai et al., 2019). The academic pressure in cities is higher than that in rural areas, which not only leads to heavy courses, but also high expectations of families and society, which leads students to use their eyes at close range for a long time, including reading, doing homework and using electronic equipment, which increases eye fatigue, interferes with eyeball adjustment and accelerates the development of myopia. Therefore, the myopia rate of urban students in all school age groups is higher than that in rural areas, and myopia is younger and higher, which requires more glasses correction. This not only reflects the direct influence of educational pressure on vision, but also shows the challenges and risks of children and adolescents' visual development in different living environments (Y. Wang et al., 2016).

In terms of lifestyle, the formation and development of myopia are closely related to many bad habits, among which excessive use of eyes, incorrect reading and writing posture and less outdoor exercise time are the most obvious reasons (Yi & Li, 2011). Most students often ignore the importance of eye health in daily life, especially when doing close work, such as reading, homework or using electronic equipment, they often concentrate for a long time without realizing that they need to take a short break to relax their eyes, which makes their eyes tense for a long time and can't get enough rest and recovery, thus aggravating the fatigue of their eyes (B. A. Holden et al., 2016).

Near work has been identified as a risk factor, but its association with myopia is weak and difficult to quantify (We et al., 2023). Xia et al. (2018) investigated 20,255 primary school students in Beijing and found that improper reading and writing posture resulted in higher prevalence of myopia (OR=1.5). In their studies, Jones et al. (2007) and Dirani et al. (2009) suggested that compared with teenagers with normal vision, nearsighted teenagers show significantly less time to participate in outdoor activities. Myopic teenagers often need to devote more time and energy to short-distance learning tasks, such as reading, doing homework and using electronic equipment, which limits their possibility of participating in outdoor activities to some extent. On the contrary, those teenagers who often participate in outdoor activities are exposed to natural light for a long time, and their eyes are fully overlooked and relaxed, thus reducing the risk of myopia. Outdoor activities can not only promote the normal development of the eyeball, but also help to relieve the fatigue of the eye and improve the visual adaptability

and adjustment ability (Parssinen et al., 2014).

2.1.2 Socioeconomic impacts of adolescent myopia

2.1.2.1 Impact of adolescent myopia on medical expenses

With the increasingly serious problem of myopia, the economic cost caused by myopia has gradually become a widespread concern of all walks of life. The economic cost of myopia can be divided into two categories according to different subjects, one is the economic burden on individuals and their families, and the other is the economic impact on society (Bullimore et al., 2021). However, scholars differ about this understanding.

The study of Rein et al. (2006) believe that the economic burden of myopia should include three contents. For example, the direct medical expenses are the most intuitive and easy to quantify part of the economic burden of myopia, which includes the expenses incurred by patients for optometry, glasses, contact lenses, laser correction surgery or other ophthalmic treatments. In addition to direct medical expenses, myopia also brings other direct expenses. For example, myopia patients need to change glasses or contact lenses regularly, which involves additional expenses such as maintenance, cleaning and replacement of glasses frames and lenses. In addition, myopia may also affect the daily life of patients, such as the need to buy magnifying glasses, anti-blue glasses and other auxiliary tools because of poor eyesight, which are other direct expenses brought by myopia; In addition, the loss of productivity caused by myopia is the most hidden and difficult to quantify part of the economic burden of myopia. Y. F. Yang (2018) considered that the economic burden of myopia on individuals comprises direct expenses in diagnosis, treatment, optometry, optical spectacles, transportation, follow-up and other aspects, and indirect expenses arising out of work relays, limitation of motion, and caregiver engagement. Medical expenses and costs related to loss of productivity incurred by myopia are a huge burden every year across the world. As the patients' myopia degree and years of myopia increase, medical institutions need to invest more resources and funds to meet their demands for vision correction. This is because as degree of myopia increases, the patients need to undergo more complex and expensive treatments, such as surgeries and high-end glasses. These treatments are not only costly, but also require medical institutions to invest more manpower and material resources to ensure that they work effectively and smoothly.

Many scholars have studied personal direct expenditure and indirect expenditure caused by visual impairment. Although the studies on the economic cost of myopia are not comprehensive, it is obvious that myopia causes great economic burden (M. C. Yang et al., 2017). To date, the

most comprehensive data on vision-related medical expenses comes from Singapore, one of the countries with the highest prevalence of myopia in the world. Through statistical analysis, it was found that the direct cost of myopia treatment for adolescents in Singapore is about USD25 million per year (Saw et al., 2008). A study with children aged 12 to 17 years carried out in 2006 found that the average annual expenses directly incurred by myopia was S$222, approximately US$148, and the median was S$125, approximately US$83 (Lim et al., 2009). It is reported that the annual expenses directly incurred by myopia in 40+ population was S$900, approximately US$709, in 2011, of which 65% (S$588, or US$463) was related to vision products and optometry. Compared with children, older people have higher individual expenses, partly attributed to complications of myopia (Griffiths et al., 2015).

Affected by the increased risk of myopia complications such as retinal detachment, glaucoma and cataract, the direct economic costs borne by myopia patients, including the cost of glasses purchase, eye examination and treatment, will continue to rise with age. These costs not only bring economic burden to individuals and families, but also may affect the quality of life and work ability of patients. In view of the increasingly popular trend of myopia in the world, especially the obvious increase of myopia rate among children and adolescents, all sectors of society should pay more attention to myopia, strengthen the popularization of myopia prevention and control knowledge, and take effective measures to slow down the development of myopia and reduce the incidence of myopia, thus alleviating the social and economic pressure that may be faced in the future (Smith et al., 2009).

The ever-expanding population suffering from myopia brings a huge economic burden to the society (Quek et al., 2004). The economic impact of on society can also be summarized in two aspects: direct economic burden and potential productivity loss. The survey data showed that the socioeconomic costs caused by various types of visual defects were RMB 684.283 to 691.090 billion in China in 2012, accounting for 1.317% to 1.330% of the year's GDP (Z. Guo et al., 2020). With the increasingly serious problem of students' myopia, the increasing degree of myopia has become an educational health problem that can not be ignored. In order to effectively cope with this challenge, schools need to take active measures to increase and optimize some special vision care facilities, create a learning environment more conducive to vision protection for students, effectively reduce their visual burden and reduce the risk of myopia. At the same time, it also reflects the deep concern and high responsibility of the school for the healthy growth of students, which is helpful to cultivate students' health awareness and self-protection ability.

In addition, the schools can examine students' vision on a regular basis by adding additional

eye examination equipment, such as visual charts and eye examination instruments, organizing regular vision examination, and inviting professional physicians or ophthalmologists to the school to carry out examination and provide guidance for students. All of these measures incur medical costs and cause some degree of financial burden. Naidoo et al. (2019) found that the average annual direct expenses related to myopia for each participating in the survey was USD 709. Pascolini and Mariotti (2012) found that more than 150 million myopia patients worldwide were uncorrected, among which about 8.70 million were blind, resulting in the potential economic loss of about USD 268 million. Based on data from people aged 50 to 65 years in Japan, Brazil, Nigeria, the United States, Mexico, Pakistan, Honduras, Australia, and Malaysia, Xulu-Kasaba and Kalinda (2022) concluded that the socioeconomic loss attributable to moderate to severe visual impairment was USD 100 million to 16.5 billion.

The direct economic burden of myopia on society shows a yearly increasing trend, and the loss of potential productivity incurred by myopia cannot be ignored (Leasher et al., 2016). Naidoo et al. (2019) concluded through meta-analysis that the global loss of potential productivity associated with the burden of uncorrected myopia was estimated to be approximately USD 244 billion in 2015. The productivity loss attributed to severe visual impairment and blindness was estimated at USD 94.5 billion in 2019 and expected to increase to USD 229.3 billion in 2050 (Kandel et al., 2018).

Residents of high-income countries usually enjoy more abundant and high-quality resource allocation because of their high level of economic development. Compared with low-income or middle-income countries, their medical and health systems are usually more perfect, medical facilities are more advanced, and medical services are more convenient and efficient. Therefore, residents in high-income countries have more choices and better conditions in preventing and treating myopia, thus reducing the prevalence of myopia to some extent. This further reflects the far-reaching influence of economic development level on residents' health status and the important role of medical resources in ensuring residents' vision health (Kandel et al., 2017). The economic burden brought by myopia to individuals and society should not be ignored, and research on myopia is of great significance (F. Wang et al., 2019). However, although the prevalence of myopia is increasing year by year, it has become a public health problem with wide influence, and the public health cost and economic cost caused by it are also rising, which brings a heavy burden to society and individuals. In fact, this problem has been largely ignored (W. Wang et al., 2017).

2.1.2.2 Impact of adolescent myopia on national government

Adolescent myopia can affect relevant individuals, while producing some social problems. The prevalence and severity of myopia in adolescents also have long-term effects on the nation's human resources. As adolescents with myopia gradually come of age and join the society, they may face limited employment options when compared with people with normal vision. Myopia may also increase the risk of vision fatigue and eye discomfort in scientific and technical workers who need to use electronic devices for long periods of time, affecting their work efficiency and productivity. Aside from that, many majors have well-defined requirements on students' vision level. For example, military academy and majors in aviation and criminal investigation only recruit students with normal vision, putting limits on many students with myopia when applying for a major or choosing a career path in the future. Therefore, myopia can affect a patient' recruitment and employment in certain occupations. As a consequence, a large number of adolescents with myopia will have to give up or not be allowed to enter these occupations, thereby leading to a brain drain and decline in the country's competitiveness in related fields.

Teenagers and children, as the future and hope of the country, their vision health has increasingly become the top priority of myopia prevention. In the era of rapid development of information and digitalization, the problem of myopia among teenagers has become more and more prominent, which has become a social public health problem that can not be ignored. If the population of myopia continues to increase at the current trend, there will be a huge gap in professional labor force that meets the vision requirements in fields that are highly dependent on vision standards, such as aerospace, precision manufacturing, and military. This gap will not only restrict the development of related industries, affect the speed and quality of scientific and technological innovation, but also directly threaten the sustainable development ability of economy and society and the overall security of the country. In addition, the rising prevalence of myopia among teenagers will bring greater pressure on the education system. From a more macro point of view, the problem of juvenile myopia is also related to the national defense security. A young generation with healthy eyesight is an important cornerstone of the country's future national defense force.

Therefore, the relevant departments should attach great importance to and pay attention to the nearsighted teenagers, ensure that they can get scientific and professional treatment in time, and strive to reduce the incidence and progress speed of myopia, so as to contribute to protecting the eyesight health of teenagers, safeguarding national defense security, promoting scientific

and technological progress and sustainable economic and social development (J. Chen et al., 2024).

In aerospace, precision manufacturing, military and other fields, there exists a huge gap in the labor force that meets the vision requirements, which will directly threaten the sustainable development of economy and society and national security. Yin et al. (2018) suggested that if the problem of juvenile myopia is not effectively controlled, its potential negative impact may bring severe challenges to the security and stability of the country. As an important reserve soldier of the modern army, teenagers are an important part of the country's future war potential. In the modern war, the wide application of high-tech weapons and equipment puts forward higher requirements for soldiers' eyesight. Whether it is to operate a complex electronic warfare system or to strike a target accurately, soldiers need excellent eyesight to ensure the smooth completion of the task. In addition, the problem of juvenile myopia may have a far-reaching impact on the development of the country's national defense industry. The national defense industry needs high-quality technical personnel to support it, and poor eyesight may limit the development of young people in professional fields, especially in positions that require high-precision operation and keen observation ability. This will cause the national defense industry to face difficulties in talent selection and training, and then affect the research and development and production of weapons and equipment, and ultimately weaken the country's overall national defense strength.

The growing prevalence of myopia in Chinese adolescents has imposed a serious restriction on the future selection of military personnel (G. X. Song et al., 2003). It is found that with the increasing phenomenon of myopia aging, the rate of vision compliance in conscription physical examination is showing a downward trend year by year. This not only reflects the seriousness of the eye health problems of contemporary teenagers, but also directly leads to a significant reduction in the number of qualified people in the recruitment process. The original abundant reserve of soldiers has been greatly reduced by the non-combat attrition factor of visual impairment, and the contradiction of difficult recruitment has become more and more prominent, which has become a bottleneck that cannot be ignored in the construction and development of the army (C. Li & Wang, 2014). In physical examination for conscription in Xiangyang District, Xiangyang City from 2012 to 2014, the pass rate of ophthalmic examination was only 52.17%, and the number of people passing the first physical examination in the three years did not reach the assigned number of conscripts (D. S. Zhang & Zhang, 2015).

At present, recruits have different degrees of eye diseases and vision abnormalities. This has become an increasingly prominent problem in the re-examination of recruits, and will

greatly affect the training and comprehensive combat capability of Chinese forces (especially field forces) (C. Ma et al., 2008). The minimum visual acuity standard for conscripts in China is continuing to be lowered. The current minimum standard is the unaided visual acuity of no less than 4.6 in the right eye and no less than 4.5 in the left eye. People whose visual acuity meets the standard without complications more than half a year after corneal laser refractive surgery are allowed to be enlisted (J. H. Xiao et al., 2015). Although the direct threat of myopia to the human resources of the national defense department can be alleviated to some extent by moderately relaxing the recruitment standards in the short term, from a long-term perspective, if we take a laissez-faire attitude towards the trend of myopia becoming younger and do not take effective measures to curb it, it will pose a major threat to China's national security and social stability.

Teenagers are the reserve soldiers of the modern army and the future age-appropriate population. With the rising prevalence of myopia among teenagers in China, the selection of future military personnel has been seriously restricted (J. H. Xiao et al., 2015). With the worse younger-age trend of myopia, the success rate of conscription gradually drops, and the difficulty in conscription becomes increasingly prominent (L. Li et al., 2022). In physical examination for conscription in Xiangyang District, Xiangyang City from 2012 to 2014, the pass rate of ophthalmic examination was only 52.17%, and the number of people passing the first examination in the three years did not reach the assigned number of conscripts. At present, recruits have different degrees of eye diseases and vision abnormalities. This has become an increasingly prominent problem in the re-examination of recruits, and will greatly affect the training and comprehensive combat capability of Chinese forces (especially field forces) (W. G. Jia et al., 2013). The minimum visual acuity standard for conscripts in China is continuing to be lowered. The current minimum standard is the unaided visual acuity of no less than 4.6 in the right eye and no less than 4.5 in the left. People whose visual acuity meets the standard without complications more than half a year after corneal laser refractive surgery are allowed to be enlisted (W. Gao et al., 2013).

Vision is the most important sense in flight activities and it was reported that 80%~90% of external information required for flight is obtained via visual channels (X. Y. Jia et al., 2024). Good visual function is a requisite for pilots to complete daily training and wartime flight tasks. The accuracy and timeliness of visual information is directly related to the safety and efficiency of flight, and it is an indispensable part to ensure the smooth completion of flight tasks. As the medical selection of modern Air Force flight cadets has extremely strict requirements for vision, the elimination rate of ophthalmic examination has always ranked first in recent years (L. S. Qi

et al., 2016). Vision, as an important indicator of ophthalmic examination in the physical examination for pilot recruitment, has always been a concern of researchers at home and abroad on medical selection criteria (Z. K. Zou et al., 2014). As the aviation industry rapidly develops and high-performance fighters and space equipment have high precision, higher vision requirements have been made in the selection of pilots in recent years. Meanwhile, under the new situation of higher requirements for educational background, the source of pilot cadets of the China's Air Force is getting less, and a wide array of pilot candidates with good potential may be eliminated.

The influence of myopia in the military field cannot be ignored. With the increasing number of young people with myopia, those teenagers who originally had the potential to become outstanding students in the military field such as the Air Force may be rejected because their eyesight is not up to standard, which directly leads to a significant decrease in the number of future military talents who meet the high standards of physical fitness and eyesight. If this trend continues, it will undoubtedly have a far-reaching impact on the overall combat effectiveness of the air force, and then threaten the fundamental interests of the country's national defense security. Especially in military operations and battlefield environments that require extremely high eyesight. Myopia patients may encounter a series of challenges, which are directly related to their performance and ability on the battlefield. These challenges are directly related to their survivability on the battlefield, operational efficiency and the fluency of teamwork.

First of all, myopia will directly affect the military's ability in target recognition. On the battlefield, it is very important to identify the target quickly and accurately, but myopia may cause soldiers to be unable to see the target clearly at a long distance, thus increasing the risk of misjudgment and missed judgment. The decline of this ability will directly affect the operational efficiency and combat effectiveness, and put the army at a disadvantage on the battlefield. Secondly, myopia will also affect the long-range shooting ability of soldiers. In shooting training, accurate aiming and shooting are the basic requirements, but myopia patients may not be able to aim at the target accurately because of vision problems, which will greatly reduce the shooting effect. This will not only affect the results of shooting training, but also cause great losses in actual combat. Besides, myopia also poses a direct threat to the long-range shooting ability of soldiers. In shooting training, accurate aiming and shooting often means survival and victory. However, even if myopia patients are equipped with the most advanced sight, they may not be able to achieve the best aiming due to the limitation of vision, which will greatly reduce the shooting accuracy. This will not only affect the results of shooting training, but also cause great losses in actual combat. In the complex and changeable scene of fighting

at night, the challenge of myopia patients is more severe. Night combat requires extremely high visual perception ability, and good night vision ability and quick adaptability to the environment are essential skills for soldiers. However, myopia patients may have limited vision, so it is difficult to effectively identify the topography and judge the enemy's situation in the dark environment, which increases the risk and uncertainty of combat. This may lead to passivity due to misjudgment and endanger the safety of individuals and teams.

In addition to directly affecting the operational effectiveness and combat capability, myopia may also have an adverse impact on the selection and training of military personnel. With the increase of adolescents with myopia, industries such as aerospace, marine technology, military technology, and advanced technology that have higher vision requirements for workers will face a shortage. These industries are critical for the national defense security and the development of high technologies. However, myopia may result in a decrease in satisfactory excellent talents, and thus affect the development of these industries and the research and development and manufacturing of national high technologies and core technologies. For example, Air Force pilots are the main fighting force of the Air Force, however, myopia poses a huge challenge to the selection and training of pilots. To ensure that pilots' vision is up to standard, the Air Force uses scientific medical selection criteria to recruit pilot cadets. The selection criteria require cadets to have excellent physical and psychological quality and to meet certain standards for vision.

A number of relevant national policies also set out clear specifications and requirements for myopia prevention and control in primary and secondary schools. In August 2018, the Ministry of Education and other seven departments issued the *Implementation Plan for Comprehensive Prevention and Control of Myopia in Adolescents and Children*, which details the work of myopia prevention and control in primary and secondary schools from the perspective of reducing students' academic burden, strengthening examination management, improving visual environment, adhering to eye exercises and other eye-care measures, and promoting outdoor physical exercise. In April 2021, fifteen departments, including the General Office of the Ministry of Education, issued the *Bright Action Work Plan for Prevention and Control of Myopia in Adolescents and Children* (2021-2025). The work plan proposes 8 main tasks, including guiding students to care and protect eyes, reducing academic burdens, promoting outdoor activities and physical exercises, advocating the scientific and standardized use of electronic products, and implementing monitoring of vision health. These tasks require the proactive cooperation and extensive participation of primary and secondary schools.

In addition, the *Guidelines on Appropriate Techniques for Prevention and Control of*

Myopia in Adolescents and Children (Updated Version) provides primary and secondary schools with the latest technologies and methods for myopia prevention and control. The guideline provides specific guidance and suggestions from all aspects of myopia prevention and control, screening to treatment. This provides an important reference for schools when implementing relevant works. In the *Guidelines on Prevention and Control of Myopia at Different Learning Stages in Preschools and primary and secondary school,* corresponding myopia prevention and control strategies are formulated for students of different ages. These guidelines take into account the physiological characteristics and learning demands of students and provide the schools with more precise guidance for myopia.

China has also issued and implemented a series of national standards, to better standardize the prevention and control of myopia in primary and secondary schools. These standards provide comprehensive specifications in terms of teaching environment, school supplies, health education and other aspects. Among them, the *Hygienic Standard for Day Lighting and Artificial Lighting for Middle and Elementary School* and *Hygienic Requirements of Lighting Design and Setting in Primary and Middle School* put forward clear requirements on the construction of light environment of classrooms in primary and secondary schools. These standards stipulate daylight factor, lighting & illuminance, uniformity of illuminance and other parameters of classrooms, with a view to creating a bright, comfortable learning environment and reducing the risk of visual fatigue and myopia due to insufficient or excessive lighting.

In addition, the *Hygienic Requirements of Study Products for Myopia Prevention and Control in Children and Adolescents* stipulates hygienic requirements of study products for myopia prevention and control. including paper quality, font size, line spacing, and other parameters of study supplies, such as textbooks, teaching auxiliaries, study magazines, and exercise books. These requirements are intended to lower the risk of vision fatigue and myopia in students, caused by reading for a long period of time or using substandard school supplies. The *Requirement of Health Education in primary and secondary School* stipulates the general requirements, implementation goals, educational contents, implementation methods, evaluation suggestions of health education in schools. It includes eye care and other contents related to myopia prevention and control, which aims to enhance students' awareness of myopia through health education and help them master the correct eye-use habits.

2.1.2.3 Impact of adolescent myopia on individual development

As an essential condition for engaging in social activities, visual function is also crucial for students in daily learning and living (Cui et al., 2018). The progression of myopia is

characterized by progressive superposition and irreversibility (G. Wen et al., 2013). Myopia will accompany patients all their lives. If low myopia is not controlled in time, it will further deteriorate into high myopia, and the risk of visual damage faced by patients will increase significantly, and may even lead to blindness, further aggravating the limitations of patients in their lives, thus causing more serious and far-reaching restrictions on their lives. High myopia is a major cause of myopic macular degeneration, which can lead to vision impairment and even blindness. The probability of the occurrence of secondary rhegmatogenous retinal detachment in these patients is significantly higher than that in normal population, which will seriously affect the patients' vision (X. Li, 2003). The nuclear density of cataract lens is also higher compared with normal population, and the probability of the occurrence of nuclear cataract is greater (Praveen et al., 2008).

Myopia patients, especially adolescents, may have psychosocial barriers and negative social attitudes such as fear of discrimination and bullying (Morjaria et al., 2019). Because teenagers are at the key point of physical and mental growth, their psychology and physiology are still developing rapidly, and the psychological resilience has not been fully established. Faced with the complex environment of multiple factors such as academic pressure, interpersonal relationship, family environment and social expectations, they are often more prone to emotional problems such as anxiety and depression (Q. Li et al., 2020). Angi et al. (1993) found that myopic college students had higher anxiety than the control group. Lazarczyk et al. (2016) found that myopia would aggravate their trait anxiety level, and such phenomenon was more serious in boys. It has been found that when an individual's vision was impaired, the prevalence of depression was at least twice that of the normal population (Kremen et al., 2012).

Anxiety and depression are the main reasons that lead to the decrease of the quality of life of myopia patients. Ayaki et al. (2016) applied Pittsburgh Sleep Quality Index and Hospital Anxiety and Depression Scale in their study, and found that people with myopia had problems of staying up late and sleeping for a short time, especially those with high myopia. Therefore, long-term psychological stress is not only the result of myopia, but also may cause continued deterioration of vision (Sabel et al., 2018). Affected by vision, the long-term visual impairment faced by myopia patients will gradually form a specific behavior pattern, which is often closely related to introverted personality tendency or social avoidance behavior characteristics. Due to poor eyesight, nearsighted patients may feel uncomfortable in social occasions, fearing that they can't clearly see other people's expressions or reactions, thus gradually reducing their willingness to participate in social activities, preferring to be alone or avoiding occasions that require close visual communication. This psychological and behavioral change has further

aggravated their sense of social isolation and formed a relatively introverted and social-avoiding behavior pattern (Y. Y. Wang et al., 2019). Beedle and Young (1976) found in their study that myopia patients showed introverted personality patterns, while hyperopia tends to form extroverted personality patterns. Y. L. Zhou and Huang (2010) found that myopia caused impact on students' personality, most significantly their personality becoming introverted.

With the increasing prevalence of adolescent myopia, the quality of life of myopia patients has gradually attracted the attention of scholars. Myopia patients, especially those with high myopia, are affected by visual function and by psychology and economic factors, and their quality of life is impaired to varying degrees (S. Y. Zheng & Wang, 2024). E. S. Yang (2009) found that the vision related quality of life of patients with high myopia was seriously damaged. The vision-related quality of life of people with high myopia was significantly lower than that of those with emmetropia, mild and moderate myopia, and even reduced to a level similar to that of patients with severe keratopathy. Improving the vision related quality of life is one of the main goals of ophthalmologists in China, and it is also one of the main tasks of “Vision 2020” (S. Y. Wang, 2022).

Poor eyesight is not a simple health problem, it profoundly affects the all-round development of teenagers, from cognitive learning, daily life to social ability, all of which are directly or indirectly affected by it. It is found that poor eyesight will hinder teenagers' study, bring them a lot of inconvenience in their study and life, hinder their normal interpersonal communication and development, and the rising incidence of myopia among teenagers also increases the educational pressure (Niu & Dong, 2023). Studies have shown that poor vision and uncorrected visual defects of adolescents will have a negative impact on their academic performance (Qiu et al., 2017). According to some relevant studies, it is found that providing glasses for children with uncorrected myopia can improve their academic performance (Z. Song, 2017). Myopia makes it difficult for myopic patients to clearly and accurately capture other people's facial expressions and communication signals, which brings significant troubles to daily life and study activities. Due to the visual limitations, they will encounter obstacles when interacting with others, and then they will easily fall into the question of self-worth. This persistent frustration often causes myopia patients to be socially isolated and resist interaction and contact with the outside world (Meng et al., 2010).

The increasing prevalence of myopia among adolescents increases the educational pressure, as the disease will affect the accuracy of teenagers' reading, and upon accurate reading, slow down their reading speed. Higher myopia may lead to reduced visual acuity, which reduces also the ability to see distant objects, the need to rely more on eyeglasses or contact lenses in life, as

well as a reduced ability to adapt to life after vision loss, which can negatively affect daily activities, learning, and socialization.

Different types of myopia, such as simple myopia and high myopia, may have different impacts on quality of life. Once myopia develops into high myopia of 600 degrees or more, the health of the eye is more at risk. Patients, especially those with high myopia, are affected by a variety of factors, including visual function, psychology, and economics, all of which have varying degrees of impairment in the quality of survival. Cui et al. (2018) found that the visual quality of life of patients with high myopia has been severely impaired. The vision-related quality of survival of people with high myopia is significantly lower than that of people with orthopnea and mild to moderate myopia, and is even reduced to a level of quality of life similar to that of patients with severe keratoconus (Lipson et al., 2022). If ordinary myopia progresses to high myopia, significant visual impairment, or blindness, it can be even more limiting for patients, limiting their choices in life even more. Patients need not only prompt medical attention to correct their current myopia, but also regular and long-term follow-up.

The purpose of regular and long-term follow-up is not only to monitor changes in the disease but also, to detect complications of high myopia in a timely manner (Han et al., 2023), even if there are no complications and no retinal pathologic changes, and the patient's quality of vision has deteriorated. D. Wang (2019) pointed out that the longer the course of myopia lasts, the more obvious and sustained the downward trend of its visual life quality. Prolonged wearing of glasses also puts the ciliary muscles under long-term tension and reduces the elasticity of the lens, resulting in the anterior and posterior diameters of the eyeballs becoming longer and excessively protruding, the orbits collapsing, and some of the ocular muscles atrophying, which affects the visual quality of life of myopic primary schoolchildren, and the improvement of the quality of life of the visual quality of patients with myopia is one of the main objectives of the staff of the ophthalmology department in China, and also one of the main work tasks of the Vision 2020 It is also one of the main tasks of "Vision 2020". Improving the level of visual acuity, in turn, contributes to the quality of life of people (Virgili et al., 2020).

2.2 Research progress on stakeholder theory

2.2.1 Concept of stakeholder

Stakeholder is an important basic concept of this study. The term “Stakeholder” is interpreted as "party in interest" or "interested party". We adopted the interpretation of "stakeholder" that

is widely recognized among most scholars. Since then, dozens of relevant definitions were proposed, all of which are inconsistent, and a consensus has yet to be reached. The concept of stakeholders, which is now accepted by more scholars and researchers, describes "stakeholders as all individuals and groups that can influence the achievement of an organization's goals or are affected by the process of achieving an organization's objectives. Dozens of stakeholder-related definitions have appeared before and after this classic definition was proposed, reflecting a primary challenge in the analysis concept of stakeholder, that is, how to establish a broadly acceptable definition of the term “stake” (Elms et al., 2002).

The concept of stakeholder can be interpreted in a "narrow" and "broad" view. The narrow view describes stakeholders as "groups or individuals who interact with and have a claim or an interest in a firm" (Fares et al., 2021), which highlights the interests that stakeholders care about. Clarkson and Max (1995) divided stakeholders into the primary and secondary stakeholders based on social connections and close relationships between stakeholder groups and related enterprises. The stockholders, investors, employees, customers, and suppliers are primary stakeholders, while communities, governments and media are secondary stakeholders. For the broad view, stakeholders can be "expanded to include anyone" (Mitchell et al., 1997), and the broad sense has “the advantages of wide meaning and inclusiveness".

In the mid-1970s, the stakeholder theory was gradually recognized and accepted by western enterprises. In this context, Wharton College took the lead in setting up a special stakeholder management course. It aims to deeply integrate and effectively apply the ideas of stakeholders into the strategic management system of enterprises, so as to help enterprises better understand and deal with the interests and influences from all sides. With the passage of time, this theoretical framework has been enriched and perfected in practice, and finally a relatively mature and systematic analytical framework has been formed, which provides strong theoretical support and practical guidance for the sustainable development of enterprises. Stakeholders exist corresponding to the traditional concept of stockholder, which plays a vital role in enterprise theory and practice.

The stakeholder theory appears as a subversive image of the theory of shareholder supremacy. Before the concept of stakeholders was widely popular, American business circles generally pursued the principle of "shareholder first", and the core of this concept was to pursue "maximization of shareholder value", that is, all decisions and actions of enterprises should focus on improving shareholders' interests and returns. The concept of "maximizing shareholder value" is largely realized at the expense of the legitimate rights and interests of other stakeholders. For example, in order to get high economic returns in a short time, operators will

take a series of short-term actions, such as cutting R&D expenditure, lowering product quality standards, ignoring employee training and welfare, and overusing environmental resources. Although these short-sighted behaviors may bring some profit growth to enterprises in the short term, they will have a serious negative impact on the sustainable development of enterprises in the long run. More seriously, this excessive pursuit of shareholders' interests may also lead to a series of complex and far-reaching social problems, such as the damage to consumers' rights and interests, the deterioration of employees' working conditions and treatment, the intensification of environmental pollution, and the tension in community relations. These problems will not only damage the social reputation and brand image of enterprises, but also adversely affect the harmony and stability of the whole society.

2.2.2 Identification and classification of stakeholders

Since the 1960s, the research on stakeholder theory has been deepening around the concept definition, classification, behavior interpretation and management strategy of stakeholders, and follows the research logic from individuals to relationships to networks. In terms of stakeholder classification, in the process of deepening the stakeholder theory, Clarkson and Max (1995) classified stakeholders into primary and secondary stakeholders based on how close they are to the corporation, the primary stakeholders are defined as those groups that can have a direct and significant impact on the operation and decision-making of enterprises. They usually include core elements such as shareholders, customers, employees, suppliers and creditors. The interests of these groups are closely related to the rise and fall of enterprises, and their satisfaction and loyalty are directly related to the market competitiveness and long-term development ability of enterprises. Without the continuous support and participation of these primary stakeholders, enterprises can hardly maintain their daily operations, let alone achieve sustainable development.

In contrast, secondary stakeholders refer to those groups that do not directly participate in the core operation of the enterprise, but still indirectly affect the operation of the enterprise in various ways to some extent. Such groups may include communities, government regulators, media, environmental organizations and academia. Although they do not have a fundamental direct impact on the survival of enterprises, their opinions, attitudes and actions can also have an important impact on corporate image, policy formulation and market environment. Therefore, enterprises need to fully consider the interests and demands of these secondary stakeholders when formulating strategies and making decisions in order to maintain a good external environment and reputation. Through such classification and identification, enterprises can

more accurately grasp the needs and influence of various stakeholders, thus formulating more comprehensive and effective management strategies.

Mitchell et al. (1997) classified stakeholders are classified according to their power, 1egitimacy and urgency. Among them, the power classification is based on the types of resources that stakeholders rely on when exercising their power. These resources are rich and varied, and formal powers, such as the rights endowed by law and the influence brought by positions; Economic power, such as influence exerted through capital control or market position; Political power, such as pressure exerted through policy making or administrative intervention; And normative power, such as binding force based on social norms, moral standards or industry standards. Urgency focuses on whether the requirements of stakeholders can quickly attract the attention of enterprise management. It reflects the urgency of stakeholders' needs and the priority of these needs on the enterprise management agenda. The requirements of some stakeholders may be directly related to the survival or reputation of the enterprise and need immediate response; Others may be considered in a broader planning cycle because of their long-term or indirect nature. The difference of urgency increases the dynamics and complexity of the relationship between enterprises and stakeholders. Elms et al. (2002) studied and developed stakeholder theory from the perspective of enterprise-stakeholder relationship, and divided stakeholders into four types based on whether the relationship is compatible and necessary, the division of these four types helps enterprises to identify and manage their stakeholders more clearly, so as to formulate more effective stakeholder management strategies. Enterprises need to adopt different management strategies according to different types of stakeholders, in order to realize the sustainable development of enterprises and fulfill their social responsibilities.

With reference to the previous research, Sheng (2009) focuses on the analysis of stakeholders' interests and power attributes, and divides the stakeholders of technological innovation into certain stakeholders, expected stakeholders and potential stakeholders according to the two dimensions of stakeholders' interests and power. Deterministic stakeholders, the stakeholders in the category have high power and high interests, they usually have a direct and significant impact on the process of technological innovation, and their interests are closely related to the success of technological innovation; Prospective stakeholders either have high power but low interests, or have high interests but low power. This kind of stakeholders play an indirect but important role in the process of technological innovation; Potential stakeholders have low power and low interests. These stakeholders do not directly participate in or influence the process of technological innovation, but their existence and

changes may have a potential impact on technological innovation.

From the above classification of stakeholders, we understand that stakeholders can be classified into various types from different perspectives and based on classification criteria. Freeman (1994) first pointed out that the interests held by stakeholders are different from their power over a corporate. Clarkson and Max (1995) from the perspective of stakeholders, this paper deeply considers their willingness to establish relations with enterprises and the motivation behind it. This willingness is not only based on their expectation of enterprise value creation, but also involves their concern about the possible impact of enterprise behavior. It also evaluates the importance of stakeholders from the perspective of the enterprise itself. Classify stakeholders from different perspectives, classify internal and external stakeholders, and put forward that stakeholder management is to match internal and external stakeholders. On this basis, the core task of stakeholder management is how to achieve effective matching between internal and external stakeholders. This means that enterprises need to establish a mechanism to ensure a dynamic balance between the interests of internal stakeholders and the expectations of external stakeholders. This balance not only helps to improve the operational efficiency and market competitiveness of enterprises, but also enhances the sense of social responsibility and sustainable development ability of enterprises. Therefore, stakeholder management is not only a strategic choice, but also the key for enterprises to achieve long-term success and sustainable development. Sheng (2009) always classified stakeholders by interests and power attributes and conducted new situation matching to dimensional delineation of stakeholders. No matter what classification criteria and methods the scholars adopt, both of them are helpful for us to have a deeper understanding of stakeholders from different research angles, thereby laying a theoretical foundation for subsequent studies on stakeholders in different fields and disciplines.

In addition, the research on the influencing factors of stakeholders mainly focuses on corporate social responsibility and corporate culture. Firstly, the research on corporate social responsibility and stakeholders. Peloza and Shang (2011) believe that corporate social responsibility activities have the potential to establish a stronger relationship between enterprises and stakeholders. Corporate social responsibility activities related to philanthropy and business practice can only make stakeholders feel altruistic, while corporate social responsibility activities in the form of products or services can make stakeholders feel altruistic and self-beneficial, so corporate social responsibility activities in the form of products or services are more likely to be recognized by stakeholders. Lian and Wang (2018) found that the disclosure of corporate social responsibility information is closely related to the behavior intention of stakeholders.

Positive social responsibility information can increase consumers' purchase intention by enhancing their recognition of enterprises, improve job seekers' job hunting intention by highlighting corporate values, and enhance investors' investment intention by reducing the degree of information asymmetry. Axjonow (2018) found that compared with professional stakeholders, non-professional stakeholders (such as consumers, employees) lack the ability to independently analyze corporate social responsibility reports, so it is difficult for independent corporate social responsibility reports to improve the reputation of enterprises by gaining the approval of non-professional stakeholders, while corporate social responsibility information published through corporate websites and other information channels is more easily captured by non-professional stakeholders, which is more conducive to improving the recognition of non-professional stakeholders and promoting enterprises.

Y. Q. Zhu and Zhou (2020) believe that a series of activities implemented by enterprises to fulfill their social responsibilities can improve employees' perception of corporate social responsibilities, help create a moral atmosphere that encourages the display of virtues within enterprises, bring healthy and upward psychological emotions to employees, and then improve employees' happiness index. J. Huang and Xue (2020) found that under the background of the new media era, the speed and breadth of information dissemination reached an unprecedented level, and the public's requirements for the transparency and authenticity of information were also increasing. Compared with those general and abstract corporate social responsibility information disclosures, those specific, detailed and targeted corporate social responsibility information disclosures show more obvious advantages and are more conducive to improving the relationship between enterprises and stakeholders.

Secondly, the research on corporate culture and stakeholders. Boesso and Kumar (2016) divided the corporate culture related to stakeholders into three types, namely egoism culture, instrumentalism culture and moralism culture. Among them, the egoistic culture only pays attention to the needs of shareholders, so his goal is to maximize short-term interests; Instrumentalism culture focuses on the long-term interests of enterprises, so its goal is to meet the needs of stakeholders that are important to enterprises as much as possible; Moralism culture focuses on the broad interests of society, so its goal is to meet the needs of all stakeholders. Ali (2017) studied the relationship between corporate culture and employee commitment. The results show that corporate culture can improve employees' sense of belonging and commitment to the enterprise, and among all the components of corporate culture, teamwork, communication, training development and reward recognition have the greatest influence on employee commitment.

S. B. Wen et al. (2018) believe that corporate culture can convey relevant information about corporate obligations and responsibilities to stakeholders, and stakeholders will form a subjective cognition of the enterprise according to the received information, thus affecting the subsequent investment in the enterprise. Bi et al. (2020) found that a corporate culture that pays attention to customers' needs and interests is not only conducive to establishing an efficient communication mechanism between enterprises and major customers, enhancing their cooperative relationship, and reducing the fluctuation of major customers, but also helps enterprises quickly identify new markets, tap potential customers, and reduce the customer concentration of enterprises. Cheng et al. (2021) studied the relationship between enterprise trust culture and supplier management, and found that trust culture is beneficial to information exchange between enterprises and suppliers, reducing the information communication cost of both parties; It is conducive to strengthening the controllability of the cooperative relationship between the two parties and reducing the management and maintenance costs of the relationship; It is conducive to strengthening the willingness of suppliers to cooperate with enterprises and expanding the range of suppliers for enterprises.

2.2.3 Evolution of stakeholder theory

According to the existing stakeholder theory, the management of stakeholders evolves from individual to relationship and then to network perspective (Lin, 2010). Among them, the study of individual perspective accounts for the vast majority, which mainly focuses on the behavior and motivation of individual stakeholders and their direct interaction with enterprises. However, there is relatively little research on the relationship perspective, especially the network perspective. The relationship perspective emphasizes the complex and subtle interrelationships between stakeholders and how these interrelationships work together in the operation and strategic decision-making of enterprises. From the perspective of network, stakeholders are regarded as nodes in an intertwined and dynamic network system, and each node is connected with other nodes through a specific relationship chain, which jointly affects the stability and efficiency of the whole system.

The essence of enterprise stakeholder management, fundamentally speaking, is the management of the complex relationship between enterprises and stakeholders. This relationship involves not only the direct interaction between individual stakeholders and enterprises, but also the complex network formed by information sharing, resource exchange and power game among stakeholders. Therefore, it is often difficult to fully reveal the complexity and dynamics of stakeholder management only from an individual perspective,

which has certain limitations. Therefore, in order to overcome this limitation, some scholars try to study the relationship between stakeholders as the basic analysis unit (Lin, 2010).

The research on stakeholder management from the perspective of relationship makes up for the interactive process that individual perspective can't pay attention to, and focuses on the structure, form and process of interaction between the two parties. To study the interactive relationship between stakeholders, it must be analyzed in the network environment to which it belongs. From the perspective of network, stakeholders are embedded in a network composed of several interconnected relationships, which provides resources for stakeholders while imposing certain restrictions. Different from the traditional research perspective, the network perspective does not pay attention to the individual attributes of stakeholders, nor does it focus on the relationship between stakeholders in isolation, but focuses on the structural model of the overall network where stakeholders are located. The research logic of stakeholder theory based on China's reality includes China's demonstration based on the classification of stakeholders, the source and management strategy of stakeholders' rights, the symmetry of stakeholders' rights, the investment of specific assets, the stakeholder management of innovation (technological innovation, complex product system innovation and social innovation), the influence of network structure on stakeholders' behavior, the study of "relationship" based on the political-economic analysis framework, the network governance of stakeholders' relations and the stakeholder's (Lian & Wang, 2018).

In recent years, with the gradual promotion of tourism construction projects in beautiful countryside and rural areas, Chinese scholars' research on stakeholders in this field has been deepened and refined. R. L. Yang and Zhou (1998) deeply integrated tourism and management, and further studied the stakeholder theory until he realized the intellectual conflict of interests of stakeholders. Pan (2017) studied the three stages of sales system: project activity, project development and project trial operation, and put forward the methods of project stakeholder identification, influence analysis and communication management. On the basis of the theory of project management knowledge system, Shen and Lin (2001) puts forward targeted stakeholder coping strategies and communication strategies through the identification, classification and analysis of stakeholders. The combination of these two strategies has solved many management problems of project stakeholders and achieved good results in project practice. Z. P. Song (2020) analyzed the role of stakeholders in promoting beautiful countryside's construction. He believed that residents, governments and enterprises had their own interests in the process of beautiful countryside's construction.

To realize the sustainable development of beautiful countryside's construction, it is

necessary for stakeholders to discover and participate in beautiful countryside's co-construction and benefit sharing. L. J. Qi (2022) summarized the stakeholders in beautiful countryside's development model as: central government, provincial and municipal governments, county governments, villagers' committee members, social organizations, design enterprises, tourism enterprises and tourists. Among them, the stakeholders in leisure tourism villages are biased towards tourists, tourism companies, villagers and village committees, while those in comprehensive governance villages are biased towards villagers, village committees, design enterprises and construction enterprises. From the perspective of stakeholders, Y. Chen (2022) established a game model of "government-tourism enterprises-consumers" to deeply study the mechanism and optimization path of rural tourism coordinated development in Chengdu-Chongqing area. By analyzing the stakeholders in the stage of rural environmental governance, S. W. Xu (2020) thinks that the establishment of the Town Xian Council is helpful to promote the goal of rural environmental governance and beautiful countryside construction.

With the continuous enrichment and improvement of stakeholder theory, scholars have made in-depth discussions on the scope and influence effect of agricultural products brands on stakeholders. X. Y. Wang and Zhu (2017) believe that the stakeholders who play a major role in brand building of origin include enterprises, local governments and brand industry associations, and the brand building effect depends on the cooperation, supervision, incentive and restraint mechanisms among brand stakeholders. X. J. Li et al. (2022) believe that the regional public brand of agricultural products is a systematic project, involving stakeholders such as production, sales, operation, supervision and management. How to coordinate and mobilize the active participation of three main bodies, namely, production enterprises, brand operating companies and local governments, is the key to realize the promotion of regional public brands of agricultural products. Among them, the main forms of participation of production enterprises include maintaining and improving product quality, and brand operating companies are laying a solid foundation for brand development. It plays an important role in enriching brand value and maintaining brand relationship. The participation of local governments is mainly reflected in policy formulation, resource integration, agricultural subsidies and market supervision.

In recent years, stakeholder theory is often used to analyze the problems in the field of education, which provides a brand-new theoretical perspective for the study of education policy and school management quality evaluation. In the field of vocational education, this theory is often used to analyze the management of higher vocational colleges, the operation of vocational education groups, school-enterprise cooperation, modern apprenticeship and so on, and has

achieved a series of research results. When defining the concept of stakeholders, scholars in vocational education are generally influenced by scholars in other fields. S. Wang (2017) pointed out that the stakeholders in school-enterprise cooperation are any organizations or individuals who gain benefits or can influence the process of school-enterprise cooperation. W. Huang and Xue (2019) about the definition of stakeholders in school-enterprise cooperation is similar, that is, groups and individuals who can benefit from initiating, promoting or undertaking school-enterprise cooperation, or have a certain impact on the realization of the goal of school-enterprise cooperation.

A few scholars, such as Ouyang (2017), draw lessons from the narrow stakeholder theory and define the stakeholders of vocational education groups as "groups or individuals who have made some special investments (such as manpower, financial resources and material resources) in the process of the establishment and operation of vocational education groups and can rely on them for the sustainable development of vocational education groups." In the future research, how to differentiate and deduce the definition of stakeholders according with the characteristics of China's vocational education based on the existing definitions is a problem that scholars should explore, and it is also the basis for in-depth study of vocational education based on this theory.

Classifying stakeholders is a key link in using stakeholder theory. By combing the representative domestic literature, we can see that there are two ways for scholars in the field of vocational education in China to classify stakeholders. One is to divide stakeholders according to experience; The second is to classify by empirical and quantitative methods. Shao (2017), a representative scholar of the first kind, divides the stakeholders in the integration of production and education into three categories according to the degree of influence or the closeness of the influence relationship, in which the core stakeholders include teachers and students in enterprises and vocational colleges. Lu and Tang (2023) is the representative scholar of the second classification method, used Likert scale to ask respondents to give scores on the legitimacy, influence and urgency of 13 subjects involved in the third-party evaluation of higher vocational education, and according to the results of the scores, 13 subjects were divided into three categories: authoritative expected type and potential type, which improved the operability and scientificity of the classification method.

As an analytical framework, stakeholder theory provides new ideas for scholars to study vocational education, and continues to develop in the field of vocational education. Some scholars tend to analyze the interests and conflicts of relevant subjects on the basis of identifying and screening stakeholders when taking the stakeholder theory as the research

perspective. Some scholars also combine game theory in their research to explore the blog behavior among stakeholders. For example, Y. B. Zhang (2019) divided the government, schools and enterprises into certain stakeholders in school-enterprise cooperation. After analyzing the game phenomenon among the subjects in school-enterprise cooperation, he put forward the interest coordination strategy among them. In addition, similar to the application of stakeholder theory in other fields, the research based on stakeholder theory in vocational education is dominated by individual perspective, and the relationship perspective is separated from the network perspective.

When analyzing problems or proposing countermeasures based on this theory, some scholars expound the problems and countermeasures from the individual perspectives of different stakeholders. For example, when S. H. Chen and Zhang (2017) describe the current situation of modern apprenticeship from the perspective of stakeholders, they all take the four core stakeholders of government, vocational colleges, enterprises and trade associations as carriers to analyze the difficulties faced by modern apprenticeship in China and their countermeasures. Some scholars also pay attention to the cooperative relationship among stakeholders. For example, when Pu and Deng (2017) studied the governance structure of modern vocational education in China from the perspective of stakeholders, they pointed out that a multi-network governance structure of "government guidance, market leadership, industry guidance and school autonomy" should be constructed, which not only pointed out the participation path of each subject, but also emphasized the "interaction" among all stakeholders.

For the application of stakeholder theory in preschool education, X. M. Hong and Ma (2015) take the Three-year Plan for Preschool Education as the breakthrough point, and regard the director, the teacher and the preschool education manager as the actual executors, participants and beneficiaries of the Three-year Plan. Although they are in their respective posts and the contents of their work are different, they all benefit from the promotion in the three-year action plan, and they are the actual beneficiaries of the three-year action plan, showing a related state with their interests. That is, although they have different positions, they all have different interests in the implementation of participation. Sun (2015) divided the stakeholders of kindergarten system governance into three categories, and made a comparative analysis from the common interest demands and contradictions of stakeholders, aiming at smoothing the interest involvement among kindergartens. The formation process of Geng (2007) policy is fundamentally the redistribution of interests, during which it is the collision and reconciliation of resource allocation. M. J. Zhang and Song (2020) divided children and parents into core stakeholders, kindergartens into important stakeholders, and education administrative

departments into indirect stakeholders through "Mitchell scoring method", in order to better understand the interests of all classes, and then put forward some feasible measures and methods for the construction of teachers.

The research on sports interests in China lags behind other professional fields in China and has made remarkable progress in recent years. Domestic scholars S. H. Wang and Ye (2005) believe that sports events include stakeholders such as host organizations, communities, media, business assistance teams, suppliers, participants and spectators. H. Y. Huang and Zhang (2008) distinguished the stakeholders of sports events from the inside and outside, and thought that the internal stakeholders included the owners and participants of the host organization, while the external stakeholders included the host government, the host community, the audience and the media. Yuan (2008) regards project associations, clubs, athletes, coaches, referees, agents, sponsors, advertisers, government, media and spectators as stakeholders in China's professional sports. Different stakeholders have different interests, among which clubs pursue the dual goals of public welfare and self-profitability: project associations focus on political goals and national interests, followed by economic benefits; Athletes pursue personal interests such as income and status; Coaches value competition results and economic benefits; Shu and Zhou (2006) think that the six major stakeholders (associations, clubs, employees, fans, media and local groups) in the professional league industry excessively seek to maximize their own interests, which leads to vicious game behavior. C. Z. Chen et al. (2009) think that professional club stakeholders such as project associations, creditors, athletes, coaches and business assistants all have the control right and residual claim right of professional clubs.

The management goal of the club should be changed from maximizing the interests of investors to maximizing the interests of stakeholders. C. M. Xu and Feng (2013) believe that the stakeholders of professional basketball clubs mainly include Chinese basketball association, athletes, coaches, referees, managers, sponsors, shareholders, fans, media representatives and local groups. X. Wang and Wang (2018), starting from the game process of property rights subject in China's professional basketball league, vertically combed the power transfer between Chinese basketball association and the basketball management center, the power balance between the professional basketball club and Chinese basketball association, the numerous competitions among the agency companies, and the complex relationship between the professional basketball club and the agency company, which showed the prospect of deepening the market-oriented and professional reform of China's professional basketball league, and analyzed the game dilemma after reshaping the property rights subject relationship in China's professional basketball league, and put forward solutions based on this.

2.3 Research progress on the stakeholders of juvenile myopia

2.3.1 Hospital

With the gradual availability of national medical equipment and the gradual increase of medical personnel, the prevention and control effect of myopia will be improved, and then the number of adolescents with myopia will be reduced. Compared with economically underdeveloped countries and regions, developed countries attach greater importance to the vision care and screening of students and take abundant and comprehensive screening measures to monitor the vision health in a more scientific and extensive manner (X. F. Xiao, 2019). The vision centers established in hospitals have an important contribution to vision improvement of adolescents (T. Fan et al., 2017). The government of China may increase the subsidies for optometry and lens fitting for adolescents, or carry out bidding and centralized procurement of myopia prevention and control products to lower their prices, making them affordable for more families, and thus reducing the occurrence and aggravation of myopia.

The prevention and control of myopia should start from "childhood" to establish a whole-life-cycle eye health system. Educational administrative authorities at all levels should continue to organize the implementation of special monitoring of myopia and health influencing factors of students, establish and improve the vision monitoring system of primary and secondary school students, take vision screening as part of the health education of these students, and conduct regular vision monitoring every year to know the vision health conditions of such students. As a matter of fact, for most students, the vision problems can be detected by simple vision monitoring (such as vision screening) and corrected by timely wearing of appropriate glasses and other measures. With the increase of the prevalence of adolescent myopia, the demand for ophthalmologists in medical institutions is growing, more and more scientific research funds are invested in the research and more optometry equipment is available to meet the needs. Meanwhile, with the deepening of the research, the number of professionals and equipment continues to increase, and adolescent myopia patients can get better diagnosis and treatment conditions and more diagnosis and treatment opportunities to help correct their myopia.

From the socioeconomic perspective, the continuous increase in the investment of medical resources tends to promote technological innovation in the medical field. This trend is particularly obvious in the field of myopia treatment. With increasing myopia patients and rising medical expenses, medical institutions, scientific researchers and enterprises have sought more

efficient, convenient and economical myopia treatments to reduce the national financial and socioeconomic pressure. By the other hand, technological innovation plays a crucial role in the field of myopia treatment and continuous R&D and practice have achieved breakthroughs in the medical field. New technologies of prevention and control, such as AI-based personalized vision training system, can make a targeted training plan according to the vision of each adolescent, thereby effectively reducing the incidence of the disease. New drug treatments that fundamentally prevent myopia by regulating the growth and development of the eyeball are also continuously emerging.

With the continuous improvement of Artificial Intelligence (AI) algorithm and the rapid development of core technology, the application scope of this cutting-edge technology in the medical and health field is expanding day by day, especially in the early diagnosis and treatment of pathological myopia. The introduction of AI technology has opened up new ideas and ways to solve this long-term puzzle in the medical field (Yu et al., 2023). The multi-focus soft corneal contact lens with peripheral defocus design distributes defocus rings on the lens surface, so that the light can form a focus on the retina in a predetermined way after passing through the lens, so as to stimulate the retina to release signals that are helpful to slow down the development of myopia. This design not only helps to slow down the deepening of myopia in children and adolescents (J. F. Huang et al., 2023). The multifocal soft contact lens with peripheral defocus design uses the optical defocus principle and multi-ring defocus R&D technology to transform hyperopic defocus into positive or myopic defocus state, control the elongation of the eye axis, and thus slow down the increase of myopia degree (Y. M. Zhang & Yang, 2022). The *White Paper on Myopia Management* issued in 2019 states "Multifocal soft lenses have a certain effect of retarding myopia progression (about 0.21 D/year) and can control 25% to 50% of axial elongation (about 0.11 mm/ year), and their myopic reduction efficacy is low to medium" (Jiang, 2019).

In addition, a double-blind randomized clinical trial shows that the myopic reduction effect of multifocal soft contact lenses depends on the additional diopter, and the higher the additional diopter, the better the myopic reduction effect (Walline et al., 2020). The first-generation peripheral defocus lens is designed to use peripheral vision control technology to reduce paracentric defocus. Vision Cooperative Research Center conducted a one-year medium-sized clinical trial on the lens, and found that the lens featuring asymmetric design and shell-like shape can effectively decrease peripheral defocus, reduce axial elongation myopia, and slow down the progression of myopia by 30% on average (Sankaridurg et al., 2010). The second-generation peripheral defocus lens is designed to use the microlens technology to reduce

paracentric defocus. A two-year wearing test demonstrates that this type of lens can effectively slow down the increase of myopia degree by 59% and reduce the rate of axial elongation by 60% (Lam et al., 2014).

There are a wide variety of vision correction methods, such as spectacle, orthokeratology lens, and corneal contact lens. Featuring wide field of view, high imaging quality, and no impact on appearance, the corneal contact lens, compared with other correction methods, requires higher medical expenses, and also provides a better effect prevention and control, thereby helping control the number of adolescents with myopia. The corneal contact lens mainly includes soft contact lens (SCL), rigid gas permeable contact lens (RGP) and orthokeratology (OK) lens. X. Y. Chen and Dai (2019) found that the orthokeratology lens can control the increase of myopia degree by slowing down the axial elongation, and thus retard the progression of the disease. Compared with spectacles and monofocal soft lenses, RGP lenses can not only provide the best visual acuity and contrast sensitivity, but also reduce astigmatism and aberration, effectively improving retinal image quality (Y. Zhang et al., 2017). J. Yang (2018) indicated that long-term wearing of SCL could seriously damage corneal endothelial cells. Obviously, further studies are required on the safety of SCL for myopia patients. T. Cai et al. (2022) found that the myopia prevention and control rate of orthokeratology lens was 59.4% during studying at school and slightly increased to 63.6% during home online learning at holidays, indicating that orthokeratology lens still has a good effect on myopia prevention and control in high-intensity eye use during home online learning at holidays.

2.3.2 School

Myopia in adolescents has become increasingly prominent as the school year increases. Specifically, the proportion of mild myopia shows a decreasing trend, whereas that of moderate and high myopia rises sharply. This not only reflects the worsening of degree of myopia in adolescents, but also reveals the severity of this situation. In response to this challenge, schools are forced to invest more funds and resources to improve existing teaching equipment and environment, in order to reduce the incidence and slow down the development of myopia.

Various regions of China have also taken a number of measures to safeguard the physical and mental health of students. In Singapore, schools have included vision screening in the school health check-up program and set up mobile optician stores in schools, and have taken measures to address myopia among children and adolescents by increasing the amount of time students spend outdoors, restricting the use of electronic devices to complete homework, teaching eye care through student handbooks, carrying out related activities during Eye Care

Week, upgrading school sports facilities, and optimizing classroom lighting (B. N. Wang et al., 2020). China-Taiwan, requires all primary and secondary schools to implement a health-promoting school program and attempts to integrate health-promoting schools with the prevention and control of myopia in children and adolescents (Y. Zhang et al., 2020). Wuhan City, with education as the main line and school as the position, has constructed a multilevel school students' comprehensive myopia prevention and control system and service network consisting of educational administrative departments, schools, families, and public welfare professional and technical service organizations, and has carried out the creation of vision health management schools and principals' studios based on the schools, and upgraded the school health rooms into intelligent students' health management principals' studios (X. W. Li et al., 2021).

To improve students' vision health, Nanjing has launched a project to upgrade and standardize desks and chairs in primary and secondary schools. The implementation of this initiative has enabled most primary and secondary school students in Nanjing to use adjustable or upgraded desks and chairs. This kind of desks and chairs can be adjusted according to the height and growth of students, providing them with a more comfortable sitting posture and visual environment, thereby relieving the stress on eyes from long-term learning. Wuhan Changqing Experimental Primary School is also aware of the impact of classroom lighting on students' vision. Although the original T5-fluorescent tube can meet the basic illuminance requirements when there is sufficient sunlight, it does not meet the national standards in terms of strobe, glare, blue ray, color temperature, uniformity.

Besides, the lighting performance of traditional fluorescent lamps gradually decreases as time passes, leading to high energy consumption. In order to create a more healthy and comfortable learning environment for students, enhancing their well-being and productivity, the school leadership made a thoughtful decision to comprehensively upgrade the lighting environment of classrooms throughout the school. Based on market research and comparison, the school finally chose Tanyuan eye-protecting classroom LED light. This kind of light stands out for its excellent characteristics, including good illuminance, a high color rendering index, and a moderate color temperature. It is also notable for being free of glare, blue light hazards, and strobe hazards, thereby providing students with more uniform and softer lighting. This, in turn, relieves their visual fatigue and reduces stress on their eyes.

2.3.3 Government

In recent years, the governments of China have gradually increased the investment in publicity

and materials for myopia prevention and control. In 2020, the Ministry of Education issued the *Notice on the Launching of Monthly Events for Publicity and Education of Myopia Prevention and Control* to clarify every March and September as education months for myopia prevention and control, which will contribute greatly to a significant result in China (C. Liu, 2020). China also introduced relevant policies to emphasize the importance of schools. For example, the *Opinions of Six Departments including Ministry of Education on Further Strengthening the Comprehensive Work of Myopia in Children and Adolescents* state measures such as improving the teaching environment of schools and increasing activities, providing a policy basis for schools' investment in related materials. In October 2016, the former General Office of the National Health and Family Planning Commission, the General Office of the Ministry of Education and the General Office of the General Administration of Sport of China issued the *Guidelines for Strengthening the Prevention and Control of Myopia in Children and Adolescents*. Multiple guidelines for primary and secondary schools are stated, such as implementing at least one vision health education activity in every semester, setting up a regular vision monitoring system, formulating a scientific work and rest system, and establishing and improving the eye exercise system.

In May 2022, the General Office of the Ministry of Education issued the *National Promotion List of Experience and Practices of Pilot Counties (Cities and Districts) of Prevention and Control of Myopia in Children and Adolescents*, promoting the "building demonstration schools of myopia prevention and control" as an excellent experience and practice. Under the current background, the selection and construction of demonstration schools of myopia prevention and control among primary and secondary schools will help comprehensively and objectively understand and evaluate the implementation of myopia prevention and control and establish advanced models of prevention and control to play a demonstrating and leading role.

Moreover, this is of great significance for reducing the high myopia rate of children and adolescents, and protecting the vision health of children and adolescents. The *National Work Plan for Priorities of Comprehensive Prevention and Control of Myopia in Children and Adolescents in 2023* recently issued by the Ministry of Education specifies that the prevention and control of myopia in children and adolescents, overall, both the myopia rate and the physical health status of the population are now incorporated into the government's performance assessment system, and local governments and schools whose physical health level of children and adolescents has declined for three consecutive years will be held accountable according to local laws and regulations.

The city of Wenzhou has created a distinctive "Wenzhou Model" for the comprehensive prevention and control of myopia in adolescents and children, which aims to lead the country in building an intelligent prevention and control system for students' vision through full coverage and digital support; setting up corresponding standard system through full-scenario prevention and control and standardization; creating an eye health management system for students through all-round coordination and closed-loop control. Myopia screening serves as a key link in this model and is carried out in all primary and secondary schools in the city at least twice a year.

To ensure the accuracy and efficiency of the screening, Wenzhou has equipped schools with networked vision test equipment and established a vision health digital archive and an information platform for myopia prevention and control. Thanks to these measures, students' vision conditions can be obtained in real time, which provides strong support for subsequent work. In addition to the myopia screening, Wenzhou is also committed to improving the teaching environment in schools and formulating standards related to myopia prevention and control. By improving lighting, illuminance and other conditions, the city manages to provide students with a healthier and more comfortable learning environment. At the same time, Wenzhou has also built a management system for healthy eye use, which involves hospital-school coordination, home-school coordination, in-class and out-of-class coordination, and in-campus and off-campus coordination, thereby realizing the closed-loop management of students' eye use. The system not only enhances students' awareness of myopia but also provides them with comprehensive eye health protection.

The government's investment in vision health of adolescents is not only reflected by funding and environmental improvements, but also by concrete steps taken in scientific and technological research and development. In the national key R&D programs of the 14th Five-Year Plan, a special priority project, Protection of Reproductive Health and Health of Women and Children, has deployed the task of "precise intervention technology and strategy for children's myopia based on vision protection". Its core goal is to establish a large, million-level database for emmetropia in children, based on which the causes and development patterns of myopia in children can be analyzed thoroughly. To achieve this goal, the Ministry of Science and Technology has not only issued detailed guidelines, but also proactively promoted the establishment of projects, to ensure that scientific research can be advanced smoothly, with a view to proposing more accurate, effective intervention strategies for myopia in children through scientific research. This task is also dedicated to discovering biological indicators that are sensitive to children's high myopia and eye-use environment risk factors. These findings

can help us gain a comprehensive insight into the cause of myopia, thus providing a basis for formulating more scientific prevention and control strategies.

In addition, the Chinese Academy of Sciences has set up the "Ming mou Chunyu" (which means spring rain that nourishes bright eyes) program to support the prevention and control of myopia nationwide. The program, composed of an interdisciplinary team, aims to explore the effect mechanism of learning lighting sources on students' vision and develop lighting fixtures that can slow down the occurrence of myopia. Through in-depth research, the program has achieved several applicable scientific findings, such as the impact of color temperature of the lighting source on the development of axial length. These results provide not only scientific and technological support for prevention and control across the country, but is also an important reference for the development of related products and the revision of lighting standards.

2.3.4 Social organization

According to social cognitive theory, publicity and education have a positive effect on people's cognition and behavior. So that, targeted publicity and education can help adolescents better understand and address the problems they face and reduce the progression of the disease. Investment of sufficient publicity resources can improve people's awareness, make stakeholders focus more on eye health, and urge them to take prevention behaviors, thereby reducing the risk of myopia. If publicity activities are widely spread and attract people's attention, more people will take preventive measures, thus reducing the incidence of myopia. Investment in publicity activities usually determines their influence.

With more efforts and higher investment in publicity and education on myopia, it will be more widely spread, attract more participants, and draw more people's attention. China National Radio and Television Administration, which plays a key role in media publicity, actively responds to the policy spirit and work deployment of the Central Government on comprehensive prevention and control of myopia in adolescents and children. They have communicated relevant policies and regulations in a timely manner, and done a good job in theme publicity in alignment with important time nodes, such as the national "Eye-Care Day". Through the broadcast of "BabyBus" cartoon series and other excellent works on related themes, the knowledge and concepts of eye care and eye protection are conveyed to children in an easy and lively way. These works are both educational and entertaining, which are highly popular in children and effectively raise their health awareness. In Xinjiang, relevant social organizations have also taken active measures to prevent and control myopia in adolescents and children. They established a publicity team for prevention and control of myopia in adolescents and

children in the autonomous region, and produced special broadcast programs in multiple ethnic languages accordingly.

Thanks to these programs, knowledge about myopia prevention and control is disseminated to children of all ethnic groups and their families. At the same time, through a series of activities, such as providing rural families with tens of thousands of free books and providing free book packages to ensure the happiness and health of every family, including books about myopia prevention and control, have been provided for children of different ethnic groups and their families. These books, which are rich in contents and diverse in form, provide valuable learning resources for children and help them better understand and master more knowledge about myopia.

Some studies have explored the influence of eye protection and care publicity activities on the incidence of myopia. M. B. Wang et al. (2022) in order to actively respond to the increasingly serious situation of myopia among children and adolescents, a series of targeted popular science propaganda work on myopia prevention and control was carried out in Chongqing, and the publicity effect was comprehensively and carefully evaluated. The results show that the popular science propaganda activity of myopia prevention and control knowledge has achieved remarkable results, which not only effectively disseminated scientific health knowledge, but also significantly enhanced the health literacy awareness of children and adolescents and their families. By participating in activities, students and parents have a deeper understanding of the causes of myopia, preventive measures and daily eye protection skills, and apply this knowledge to daily life. This popular science publicity campaign not only achieved the expected goal, but also laid a solid foundation for the subsequent prevention and control of myopia among children and adolescents, demonstrating the important role of popular science education in improving public health. Feng (2021) found that adolescents know the causes of myopia and how to protect their vision, but quite a few students do not apply this knowledge in their lives and do not pay more attention to protecting their vision, which will lead to myopia. It can be seen that public welfare education on myopia prevention exists in mobile internet, schools and communities at the emergence stage, but it still cannot attract some students' attention to myopia prevention, and the publicity of myopia prevention in all walks of life is not sufficient.

At the peak stage of myopia in primary and secondary schools, the role played by teachers and parents is particularly critical. Teachers, as the main guides during school, should always pay attention to students' eye hygiene during and after class, regularly remind students to keep correct reading and writing posture, arrange eye exercises in time, emphasize the importance

of relaxing their eyes from afar during class, and effectively integrate the concept of eye care into students' daily study life. At the same time, as the first educator of children, parents bear the dual responsibility of supervision and guidance in the family. On the journey of myopia prevention and control for primary and middle school students, the joint efforts of teachers and parents are indispensable (J. Wang et al., 2001). According to the survey of R. Zhu (2021), as an active means of educational intervention, like eyes Eye Protection Campaign plays an important role in raising teenagers' awareness of the importance of eye health. This kind of activity has significantly enhanced the awareness of like eyes eye care health among teenagers, not only taught them correct eye habits and scientific eye care methods, but also guided them to establish a health concept of "prevention is better than cure", thus promoting the effective prevention and control of myopia among teenagers from the source. This kind of publicity activities are often combined with modern scientific and technological means, such as online live broadcast, short video, interactive question and answer, etc., which makes the information transmission more efficient and extensive, and is easier to be accepted and remembered by teenagers, thus expanding the coverage and influence of health education, and is a beneficial activity worthy of promotion.

The publicity and education of myopia prevention and control is not only aimed at teenagers, but also focuses on improving parents' cognition and awareness as an important way to reduce the risk of myopia among teenagers. Pupils' eye care consciousness and behavior habits are deeply influenced by their parents' attention to eye health to a great extent. Parents are not only guardians and guides in the process of children's growth, but also play an irreplaceable key role in preventing students' myopia and imparting correct eye care knowledge and behavior (L. Li & Zhang, 2022). Shrestha et al. (2014) found that parents' lack of knowledge about eye health can cause delay in children's behavior of seeking medical advice, thus missing the optimal treatment period. Sukati et al. (2018) found that 60.1% of parents had never taken their children for vision testing, 31.7% of parents thought that their children have good vision, and 53.1% of parents had no knowledge about children's eye health.

Related research also shows that parents of myopia students generally show a certain awareness of myopia prevention and control, and master some basic knowledge of eye hygiene. In daily life, they will take some basic preventive measures, such as limiting children's time to use electronic products, encouraging children to engage in outdoor activities, and paying attention to the lighting conditions when reading. However, parents have some shortcomings in disease professional knowledge and eye supervision. Specifically, they don't know enough about the causes, development mechanism, treatment methods and the latest prevention and

control technologies of myopia, which makes it difficult for parents to make the most scientific and reasonable decisions when facing their children's vision problems. At the same time, due to busy work and lack of professional guidance, parents can't continuously and effectively monitor their children's eye use behavior (X. H. Chen et al., 2015).

Due to the lack of scientific and professional knowledge, parents of primary school students with high myopia have a limited grasp of action skills of prevention and control, and cannot provide good visual environment and eye healthcare guidance for the students at the family level. Besides, the majority of primary school students with high myopia and their parents have no correct understanding what is a preventable, irreversible and incurable eye disease. In recent years, the popularization and marketing publicity of myopia surgery has misled many parents into believing that laser surgery is an effective way to cure myopia. This wrong understanding will make parents relax their vigilance, and then cause the families' awareness of eye care to fade and the risk of myopia and the number of myopes to increase.

2.3.5 Family

Family plays a crucial role in the management and treatment of myopia, especially in terms of medical expenses. The economic capability and resource investment of the family have a direct bearing on the correction treatment and control of the disease progression. Adolescents will be more active to receive correction treatment when their families are willing to provide necessary resources and support for lens fitting and other vision correction methods. This activeness is reflected not only in the fact that they are more likely to receive vision testing and lens fitting as recommended by their doctor, but also in more willingness to follow healthy eye use habits, such as maintaining the correct reading distance and reducing the time spent using electronic devices in daily life. Such positive attitude and behavior are essential for controlling the disease progression.

The level of household expenditure is often closely related to the family's lifestyle and consumption habits. High household expenditure usually means that families have more opportunities and resources to support a healthy lifestyle. For example, such families can provide more opportunities of outdoor activities thereby reducing the time spent using electronic devices indoors. In addition, high household expenditures also allow families to purchase higher-quality vision care products and services, such as professional glasses, goggles, and vision training equipment, which can help better protect vision health of children. This is because such families have economic capabilities enough to provide children with regular vision tests, and detect and correct vision problems in a timely manner. What's more, the

families also pay more attention to developing children's vision care habits, such as teaching children to use their eyes properly and to reasonably arrange study and rest time. Such measures are helpful to reduce the incidence and progression rate of adolescent myopia.

Studies have shown that regular and regular eyesight examination, especially once every six months, plays a significant role in preventing myopia or effectively controlling its further development (Pang et al., 2009). S. X. Huang (2020) pointed out that regular eye examinations in hospitals will help to find and reduce the risk of myopia at an early stage, which will lead to a decrease in the number of children with myopia. When families cannot afford or take no account of correction expenses, adolescents may lack necessary treatment and management, and thus present the further deterioration of myopia. There are many vision correction methods, such as spectacles, orthokeratology lenses, and contact lenses. Different types of correction have an important impact on correction-related economic burden. There is a large gap in the cost of spectacles among different peoples. Especially in cities with higher levels of development, the economic pressure of lens fitting recipients is higher. However, for people with less income, due to the limitation of economic conditions, they often don't have enough ability to enjoy high-quality frame glasses, so they can only be forced to wear ordinary glasses with relatively low price and lack of quality. As a result, their myopia problems cannot be fully and scientifically corrected, and their visual condition is difficult to be effectively improved. It may even cause further damage to their visual health by wearing inappropriate or substandard glasses. This will not only seriously affect their daily life quality, but also hinder their work efficiency and career development. In the long run, it will further aggravate its economic burden (X. Tian et al., 2022).

Y. F. Yang (2018) carried out a study in patients with myopia who live in Kunming and Dali, Yunnan Province. According to the study, if it is assumed that the annual income of these patients is RMB 28,752 yuan based on conservative estimate, the average annual expenses incurred by myopia account for around 0.95% of their annual income; if it is assumed that the annual income is RMB 46,769 yuan based on rough estimation, the expenses account for around 0.58%. In this sense, the annual per capita economic burden directly caused by myopia in China is 4.14-6.79 times heavier than that in the United States. According to optometry and ophthalmology data, the direct cost of vision products is about RMB 800 per person per year (Bullimore et al., 2021). The direct costs associated with myopia increase with age. The patients need to receive regular re-examination based on myopia progression, regardless of myopia correction method chosen. As a result, a higher frequency of replacement can lead to higher medical expenses of myopia correction.

2.3.6 Individual

Myopia of students is closely related to their mental health, which may affect the development of their living habits and study habits. A study conducted by L. X. Song (2010) among high school students with myopia revealed that students with anxiety, depression or fear tend to have bad habits, lack rigorous attitude and learning adaptability, and develop poor eye hygiene habits. They are not only vulnerable to myopia, but also not confident enough. R. F. Zhao and Sun (2008) defined the mental health standards of primary school students as six aspects: intelligence development level, emotional stability, learning adaptability, objectification of self-knowledge, social adaptability and behavior habits. Good mental health is usually related to a healthier lifestyle. Social adaptability in mental health standards is an important event for students to develop good behavior habits and children's lives.

Long-term psychological stress can be a consequence of myopia, and in turn may make vision continue to deteriorate. Severe visual impairment brings many inconveniences to the learning and living of students, significantly reducing their quality of life. Especially for primary school students, their long wearing time of glasses, high diopters, severe fundus damage, and protruding eyeballs easily make them feel inferiority and anxiety in social interactions. A survey conducted by L. X. Song (2010) among 480 junior high students with myopia revealed that students who have poor mental health tend to have bad habits, lack rigorous attitude and learning adaptability, and develop poor eye hygiene habits. They are not only vulnerable to myopia, but also not confident enough. Zhen et al. (2021) identified the mental health criteria of primary school students as six aspects: intellectual development level, emotional stability, learning adaptability, degree of objectification of self-knowledge, social adaptability, and behavioral habits. Therefore, myopia in primary school students is closely related to their mental health status, and whether they are mentally healthy or not directly influences the development of their living and learning habits, which is of great practical and far-reaching historical significance for the prevention of myopia. Better academic performance may be associated with better eye habits. Students may be more self-controlled, more likely to observe good eye habits, and tend to engage in more far-sighted activities, thus reducing the incidence of myopia and lowering the risk of myopia.

The quality of life also affects the number of adolescents with myopia. Adolescents with a higher quality of life are more motivated and have more resources to manage the disease. A survey on vision health of Chinese school-age children carried out during the COVID-19 pandemic showed that taking outdoor exercises 4 to 6 times a week makes myopia less likely

to progress when compared with not taking exercise at all (Zhen et al., 2021). A study conducted by Jin et al. (2015) in school-age children living in Northeast China concluded that two additional twenty-minute outdoor breaks help delay the growth of eyeball axis, thus can prevent the occurrence and progress of myopia in the students. A cluster randomized intervention-controlled trial was conducted in Taiwan, China among 693 first-grade students from 16 schools. The intervention group carried out school-based extra-curricular outdoor activities and encouraged school-age children to participate in outdoor activities for up to 11 hours per week. The result showed that the intervention group recorded less myopia development and axial elongation and 54% lower risk of fast myopia progression when compared with the control group. This indicates that ore time for outdoor activities can deliver a significant protection against myopia in both non-myopic and myopic children (P. C. Wu et al., 2018).

Overuse of electronic screens and prolonged reading at close distance may be associated with an increased incidence of myopia among individuals. In addition, individuals who have a poor quality of life may inadvertently spend more time engaging in activities that are potential risk factors for myopia, such as prolonged screen time or inadequate outdoor activities, thereby facing a significantly higher risk of developing myopia. For example, J. Ma (2021) pointed out in study that bad eye-use behaviors such as reading too close, excessively long reading time, and improper sitting posture are important risk factors for myopia. The study of Tan and Tan (2023) has indicated that around 59.5% of students with myopia have the habit of reading too close to the text, and more than half of these students are found to hold a pen incorrectly, which may contribute to the progression of their vision problems. As the internet and intelligent electronic devices become popular increasingly, students' daily entertainment activities have changed greatly from outdoor sports in the past to activities in front of the screen, such as online surfing, live broadcasting, and mobile games. This puts a lot more stress on eyes (Hao, 2019).

Affected by myopia, myopia patients struggle to clearly and accurately perceive other people's faces and communication signals, which often leads to difficulties in various aspects of daily life and study. This situation is particularly prone to causing self-worth denial and social isolation, which not only further aggravates their already heavy psychological burden, but also potentially has a negative impact on their overall mental health., forming a vicious circle, further affecting their quality of life and social participation (Nyman et al., 2012). Adolescents with myopia, particularly, may exhibit psychosocial difficulties, such as fear of discrimination and bullying (Morjaria et al., 2019). R. F. Zhao et al. (2008) and other scholars conducted extensive research and ultimately discovered that among the 196 primary school students who exhibited inadequate mental health, 84 were myopic, representing a myopia prevalence rate of

42.86%, while among 120 students with adequate mental health, only 12 were myopic, yielding a myopia prevalence rate of 10.00%.

Adolescents in the period of rapid psychological and physiological development are more sensitive to external environmental pressure, and thus more prone to anxiety and depression (Qian et al., 2018). Costa et al. (2021) found that students with myopia consistently demonstrated a significantly higher level of anxiety compared to students who did not have myopia. When an individual's vision is impaired, his mental health is often significantly affected, leading to potential emotional and psychological challenges that can further complicate his overall well-being. Specifically, compared with people with normal vision, the probability of suffering from depression in individuals with impaired vision is significantly increased, which is at least twice as much as that in people with normal vision (Kremen et al., 2012). Anxiety and depression are the primary reasons underlying the significant reduction in the quality of life experienced by individuals suffering from myopia, Ayaki et al. (2016) found that people with myopia generally have the problem of sleeping late and insufficient sleep time, and this phenomenon is particularly prominent and serious in individuals with high myopia. This observation suggests a potential link between visual impairment and sleep patterns, hinting at a complex interplay between ocular health and quality of sleep.

2.4 Summary of literature review

As the negative effects of myopia in teenagers become increasingly prominent, relevant research has attracted great attention from the industry. Considering that the social and economic impact brought by adolescent myopia may involve multiple stakeholders, including adolescents themselves, families, schools, medical institutions, government departments and various social organizations, this study explores the internal relationship between adolescent myopia and various stakeholders from the perspective of stakeholders. Then the social and economic impact of myopia in teenagers is quantified. This study can provide effective prevention and control measures and suggestions for adolescent myopia patients and their families to help them better cope with the challenges brought by myopia. At the same time, it can also provide theoretical support and decision-making basis for government departments and relevant organizations when formulating relevant policies and improving relevant systems.

Chapter 3: Theoretical Framework

3.1 Introduction to theory

"Stakeholder" was first evolved from the word "Stockholder" and refers to any identifiable group or individual who can affect or is affected by the achievement of the organization's objectives (Mur-Veeman et al., 2003). Stakeholder was proposed by the Stanford Research Institute in 1963 (C. Chen & Wang, 2012). In the 1990s, American economist Freeman proposed the widely recognized definition of "stakeholder", that is, an individual or group whose interests or behaviors are affected by their organizations and whose behaviors can affect the achievement of the organization's objectives (Freeman, 1994). He also pointed out that the stakeholder theory refers to the management activities carried out by corporate management to comprehensively balance interests of all stakeholders (Fu, 2006).

Stakeholder theory should be based on the theory of economic democracy and organizational participation from the field of economic management (Fu, 2006). The three basic principles of stakeholder theory are "coalition of interests", "cooperative strategic posture" and "rejection of a narrow economic view of the firm" (Beedle & Young, 1976). In 1932, Doud stated that "corporate directors must become true fiduciaries who represent not only the interests of shareholders, but also other subjects of interest such as employees, consumers, and especially the community as a whole (Pirozek et al., 2015). Since the 1990s, research related to stakeholder theory has begun in China and has been widely applied to health policy analysis and the management of various types of health organizations (C. H. Li et al., 2024). Stakeholder theory began to be applied to the health field in China, and was popularized in the early 21st century, involving a variety of fields such as health policy, especially public hospital policy and medical insurance policy (H. N. Jia et al., 2019; X. Y. Chen et al., 2017).

H. C. Zhang and Zhang (2024) used the stakeholder analysis method to study the management decision-making of health education, in which the service collaboration and nursing suggestions participated by stakeholders played a key role. Multi-stakeholders play an important role in health insurance payment through the strategy of interest coordination in chronic diseases (Lei et al., 2022). Under the guidance of stakeholder theory, chronic kidney disease (CKD) management is unique, as the disease managers fully mobilize stakeholders

based on the close connection between them (X. X. Zou et al., 2022).

The roles and points of interest of stakeholders vary in different fields. In the recycled resources industry, the stakeholders are companies, government, and research institutes (Garde et al., 2020). Stakeholders in personalized healthcare are government, medical research institutes, developers of electronic information tools, and developers of clinical practice guidelines (Downing et al., 2009). Stakeholders such as patients, families, and hospitalists are critical to the design of observational comparative effectiveness (CER) studies of different medical models (Witt et al., 2012). When evaluating healthcare, patients, physicians, management, health insurance companies, and other government stakeholders view healthcare quality from significantly different perspectives (Stolk et al., 2022). Also, stakeholders such as regulators, patent medicine suppliers, and government have a great influence on controlling the quality of medicines (Amadi & Tsui, 2019).

In conclusion, we believe that the socioeconomic impact of myopia may involve multiple stakeholders, including the adolescents, their families, schools, hospitals, governments and social organizations. Among them, the indicators related to hospitals include medical resource inputs, those related to the government include governmental health policies and visual health inputs, those related to social organizations include myopia prevention and control publicity and education inputs, and those related to families include medical expenses, prescription lens expenses, and adolescent myopia prevention and control costs. Government-related indicators include government health policies and visual health inputs, social organization-related indicators include investment in myopia prevention and control publicity and education, family-related indicators include medical expenses and prescription lens expenses, youth-related indicators include youth academic level, mental health, and quality of life, and school-related indicators include material inputs.

3.2 Study hypotheses

This study is based on public databases and questionnaire surveys to obtain relevant data to quantitatively analyze the impact of adolescent myopia on the investment of medical resources, governmental health policies and visual health inputs, publicity and education inputs of social organizations for the prevention and control of myopia, family medical expenses and prescription lens costs, adolescents' schooling level, mental health, and quality of life. As far as we know, this also compensates for a lack of quantitative analysis of the relationship between myopia and its socioeconomic impact on adolescents.

3.2.1 Adolescent myopia and hospitals' investment in medical resources

From the macroscopic perspective of society, the expenditure on medical care brought about by the problem of myopia is an economic burden that cannot be ignored. These costs are mainly derived from the State's financial and social inputs into hospitals in terms of the purchase and maintenance of medical equipment, as well as the training and remuneration of medical personnel. These inputs are the basis for ensuring that medical institutions can provide high-quality and efficient medical services to meet the needs of myopic patients for vision correction. Specifically, with the continuous advancement in medical technology, vision correction surgeries, advanced optometric equipment and advanced spectacles have become important means of treatment for myopia. These equipment and technologies are often costly and require substantial capital investment by medical organizations. Meanwhile, medical personnel, as the key to medical services, also require substantial financial support for their training, remuneration and continuous professional development.

In addition to the economic burden associated with healthcare costs, the productivity cost burden associated with myopia is also significant. In 1990, the potential global losses from myopia were approximately $4.6 billion (Javitt & Chiang, 1994). A meta-analysis by Naidoo et al. (2019), yielded an estimate of the potential global productivity losses associated with the burden of uncorrected myopia of approximately $244 billion in 2015. Productivity losses due to severe visual impairment and blindness are estimated at $94.5 billion by 2019 and are projected to rise to $229.3 billion by 2050. Residents of high-income countries have a lower prevalence of myopia because of the higher availability of resources and their easier access to healthcare resources (Kandel et al., 2018). The economic burden of myopia on individuals and society cannot be ignored, and research on it is of great significance (F. Wang et al., 2019).

In summary, the increase in the number of myopias among adolescents leads to an increase in the demand for ophthalmology treatment, and without effective preventive measures, the state needs to invest more resources and funds to introduce the latest medical equipment and more specialized medical personnel to cope with the medical needs as the degree of myopia and the number of years of myopia patients' myopia may increase. Accordingly, the following research hypothesis is proposed:

H1: The number of adolescents with myopia has significant positive impacts on hospitals' investment in medical resources related to ophthalmology.

3.2.2 Adolescent myopia and investment in myopia prevention and control materials in primary and secondary schools

Due to the increasing severity of myopia among adolescents, the prevalence of myopia is mainly influenced by environmental factors, and the educational environment is a key factor in the development of myopia in students. In recent years, some epidemiological studies have shown that environmental factors such as close reading and writing, lighting, use of electronic products, outdoor activities, and eye exercises are potentially influential and closely related to the development of myopia (Cao et al., 2024). According to existing domestic surveys, the lighting & illumination of classrooms in primary and secondary schools is not optimistic. Y. Wu et al. (2019) conducted a study on the equipment of desks and chairs, lighting & illumination, per capita area and ventilation of classrooms and student dormitories in primary and secondary schools across the country. According to the result, 59.1% of primary and secondary schools nationwide have up-to-standard teaching environment and hygienic conditions. However, the results of studies carried out separately in different cities are less than satisfactory. On average, only 24.5% of blackboards and 58.1% of desks in classrooms of primary and secondary schools in Huangpu district, Shanghai have up-to-standard illuminance (S. Zhang & Luan, 2021). A study carried out by Y. Liu and Shi (2021) on visual environment of primary and secondary schools in Chengdu demonstrates that only 6.6% of blackboards and 47.8% of desks in classrooms of primary and secondary schools in Chengdu have up-to-standard illuminance on average. Ji and Jia (2014) compared the myopia status of 9 to 10-year-old students in key schools and schools for children of migrant workers. The investigation found that in the latter, seats in classrooms are more crowded, the height of desks and chairs is unreasonable, lighting in classrooms is uneven, and students' poor posture cannot be timely corrected by teachers. In such case, poor eye use habits and overuse of eyes can seriously damage the vision of school-age children and cause myopia.

In summary, adolescent myopia is closely related to students' learning environment, which highlights the primary responsibility of schools in myopia prevention and control, making them play a key role in protecting the vision health of children and adolescents. Amidst the growing concern of society about the health of children and adolescents, schools are facing unprecedented opportunities and challenges in vision health work. Against this backdrop, the schools have attached importance to the prevention and control of myopia by making it a priority of health work. They need to take necessary measures in response to these problems, such as keeping a tighter rein on students' use of electronic devices, improving learning

environment, and increasing outdoor activities. This also needs financial investment accordingly. Based on this, the following research hypotheses are put forward:

H2: The number of adolescents with myopia has significant positive impacts on investment in myopia prevention and control materials in primary and secondary schools.

3.2.3 Adolescent myopia and government's health policies and vision health investment

As the incidence of myopia rises in adolescents, the country and the whole society are paying increasing attention to this problem, and a series of myopia prevention and control measures have been implemented. For example, to further promote the myopia prevention and control, the Ministry of Education issued the *Notice on the Launch of Monthly Events for Publicity and Education of Myopia Prevention and Contro*l. To meet the needs of corresponding works, an expert team has been set up in accordance with the deployment of the Ministry of Education, to regularly carry out "Eye-care Publicity and Education Month (March of the spring semester and September of the autumn semester) activity every year (C. Liu, 2020). To improve vision health of children and adolescents, reduce myopia incidence, and strengthen the prevention and control of myopia in children and adolescents in the new era, eight departments, including the Ministry of Education and the National Health Commission, issued the *Implementation Plan for Comprehensive Prevention and Control of Myopia in Adolescents and Children* in 2018, which aims to inhibit the high incidence and younger-age trend of myopia in adolescents and children. This marks the beginning of battle against myopia, and demonstrates that the Central Committee of CPC and the State Council seek to ensure healthy growth and all-round development of children and adolescents, attach great importance to the vision health in this group, and put the prevention and control of myopia high on the agenda (Lu et al., 2010).

Faced with the severe situation of myopia in adolescents, governments at all levels have increased the investment in promoting vision health of adolescents, with a view to addressing this increasingly serious public health problem. In Gansu Province, the Department of Education has made vigorous efforts and allocated through coordination RMB 6 million yuan as provincial special funds for the prevention and control of myopia in adolescents and children, to push forward the related works in a deep-going way. To set an example, Gansu Province has also appointed 100 province-wide model schools for prevention and control of myopia in adolescents and children, and provided one-time subsidy of RMB 4 million yuan for each of these schools, to encourage more schools to participate in myopia prevention and control. Tianjin also attaches great importance to the adolescent myopia. The financial department has allocated a whopping RMB 150 million as special fund for upgrading classrooms in primary

and secondary school. This aims to reduce the risk of myopia by improving learning environment. So far, Tianjin has upgraded 28,800 classrooms in primary and secondary schools, and 95% of schools in the city are equipped with up-to-standard adjustable desks and chairs, providing students with a more comfortable and healthy learning space. Dalian has also made positive efforts in the prevention and control of myopia in adolescents. In 2022, the city invested RMB 54.27 million yuan to equip schools with adjustable desks, chairs and other related equipment and facilities. Apart from that, schools are instructed to make personalized adjustments to the height of desks and chairs before the semester starts, to ensure that the height of desks and chairs matches that of students, thereby relieving their visual pressure and reducing the myopia risk. Attaching great importance to the prevention and control of myopia in adolescents and children, Wuhan has proposed the "3·3·3" Service System for Management of Myopia Prevention and Control in Students, namely, three levels of monitoring, three types of rehabilitation, and co-management by three parties (Lu et al., 2010).

In summary, it can be seen that the vision health of children and adolescents has already become a major public health issue that threatens China's population quality, social economy and even national defense security, undermining the life health of citizens, as reflected in the public health policies that the government has issued continuously. Based on this, the following research hypotheses are put forward:

H3: The number of adolescents with myopia has significant positive impacts on government's health policies and vision health investment.

3.2.4 Adolescent myopia and social organizations' investment in publicity and education on myopia prevention and control

In view of the seriousness and prevalence of myopia among young people, the relevant departments and organizations have attached great importance to the problem of myopia among young people and adopted a series of measures to tackle it. Fully aware of the negative impact of the myopia problem on students' learning and development, major social organizations have actively participated in and supported the relevant publicity activities. These organizations have invested a lot of resources in strengthening their publicity and education activities on the prevention and control of myopia by organizing lectures, distributing publicity materials, conducting interactive experience activities and so on. They hope to raise the public's awareness of myopia and galvanize them into action about myopia prevention and control through these activities. Parents have also attached great importance to myopia as it concerns the health of every child. They hope to draw more attention to the problem of myopia through various "eye-

care" publicity activities. They proactively participate in relevant activities organized by the school to encourage their children to develop good eye-use habits. They also vigorously cooperate with doctors in treatment to provide their children with comprehensive support in myopia prevention and control.

Myopia in adolescents also affects the selection of target audiences for publicity activities. Adolescent consumers with different degrees of myopia vary in concerns and needs of eye health (R. Zhu, 2022). Patients with high myopia need to focus more on vision health and popularization of relevant knowledge. They also need more professional and personalized services in vision correction. For these reasons, they are the key audiences of publicity activities. Such a choice may help invest more resources in publicity activities, develop more targeted strategies, select target population, and evaluate effectiveness of publicity, to better improve adolescents' awareness of eye health and adjust their behaviors. Differences in degree of myopia and years of myopia can also affect publicity activities. The publicity shall be classified as much as possible based on the age group of children and adolescents, key influencing factors of vision, different stages of vision development and other factors, avoiding being unpractical or sweeping (C. Liu, 2020). On top of that, adolescents with high myopia may concern more about vision health and are more likely to vigorously participate in and respond to related publicity activities. This variation in myopia situation and the increased engagement makes publicity activities more effective, thereby encouraging agencies to invest more and focus on the impact of myopia on the effectiveness of publicity activities. Based on this, the following research hypotheses are put forward:

H4: The number of adolescents with myopia has significant positive impacts on social organizations' investment in publicity and education on myopia prevention and control.

3.2.5 Adolescent myopia and family medical expenses and lens fitting cost

Myopia will accompany patients all their lives. Therefore, the earlier myopia occurs, the greater the corresponding medical expenditures and the heavier the economic burden. From the patient's point of view, Y. F. Yang (2018) consider that the economic burden of myopia on individuals comprises direct expenses in diagnosis, treatment, optometry, optical spectacles, transportation, follow-up and other aspects, and indirect expenses arising out of work relays, limitation of motion, and caregiver engagement. With the increase of myopia degree, the likelihood of the occurrence of eye diseases such as myopic macular degeneration, cataract, retinal detachment, and glaucoma increases (Ohno-Matsui et al., 2021). A higher degree of myopia and longer years of myopia generally require a more intensive vision correction, such

as spectacles or contact lenses. Aside from that, different types of myopia may require different or more costly methods of vision correction. Complications of high myopia can lead to vision impairment and blindness, so although myopia can be corrected usually, expenses incurred by the treatment of such complications can be very expensive, resulting in more medical expenses for a family.

Generally, patients with a higher degree of myopia and longer years of myopia may have more severe vision problems, so they need to visit the ophthalmologist more frequently for more examinations and more complex treatments. This increases the direct medical expenses and lens fitting costs. Y. F. Zheng et al. (2013) found through a questionnaire survey that the average annual direct expenses related to myopia for each myope participating in the survey was USD 709. The global cost and direct expenses of myopia (including examination fees, costs of spectacles and corneal contact lens, LASIK fees, and treatment costs of complications such as cataracts, retinopathy and glaucoma) were estimated to be US$358.7 billion in 2019, and are expected to reach US$870 billion in 2050 (Agyekum et al., 2023). Importantly, these data indicate that costs associated with spectacles and corneal contact lens will be doubled, while costs associated with cataracts and myopic retinopathy are estimated to be quadrupled.

It can be seen from the above that myopia in adolescents can impose an economic burden on families. Patients with a higher degree of myopia may need more special lens or other treatments. As the degree of myopia and years of myopia increase, the medical expenses and lens fitting costs also rise accordingly. Based on this, the following research hypotheses are put forward:

H5: The degree of myopia and years of myopia in adolescents have significant positive impacts on family medical expenses and optician lens fitting costs.

3.2.6 Adolescent myopia and mental health, quality of life and academic achievement

Visual impairment impacts adolescents in learning and living in numerous ways and the discomfort and distress caused by visual impairment and related vision problems lead to psychological issues such as anxiety, worry, depression, social withdrawal, and embarrassment, particularly affecting their emotional stability (Alma et al., 2011). Mental health, broadly defined, refers to an efficient, satisfying, and sustained state of mind. Narrowly, it encompasses the completeness and coordination of cognitive, emotional, volitional, behavioral, and personality processes, enabling individuals to adapt to and keep pace with society (X. T. Huang et al., 2022). A study involving parents, teachers, and students revealed that poor or uncorrected vision in children adversely affects their attention, endurance, and academic achievement,

leading to psychological and social stress, while wearing corrective glasses can improve students' academic achievement and maintain their psychosocial health (Nael et al., 2019).

As the prevalence of myopia has increased, the quality of life of myopic patients has gradually gained attention from scholars. In general, quality of life is poorer in people with uncorrected refractive error and high myopia, as well as those with myopia-related complications. In a study of a group of 16-year-old patients, myopia was an independent risk factor for poorer quality of life. The quality of life of myopic patients was poorer in both distance and near vision (Xiang et al., 2023). Although data on the impact of uncorrected myopia on quality of life and the benefits of spectacle wear are scarce, in a study of 2,346 adolescents from a southwestern region of China with low rates of spectacle use, adolescent myopic patients who did not wear spectacles were found to have lower scores on health-related psychosocial, emotional, and social functioning aspects of quality of life (Y. Gao & Yu, 2022). Similarly, in 2 independent studies conducted in China, adolescents with vision loss had lower health-related quality of life, including aspects of social functioning and school functioning, although the study from Singapore did not find differences in quality of life between types of refractive error (Y. F. Zheng et al., 2013). The need for myopic patients to purchase and replace glasses or contact lenses frequently may cause personal inconvenience and affect quality of life. For the group with less income, they are forced to choose to wear ordinary eyeglasses because they cannot afford to enjoy high-quality frames, and their myopia may not be adequately corrected, which may be harmful to their visual health and even affect their life and work, thus further aggravating their financial burden (X. Tian et al., 2022), and the quality of their life is also reduced.

Poor vision can also cause learning obstacles for adolescents, bring many inconveniences to study and life, and hinder their normal interpersonal interactions and development (Virgili et al., 2020). In addition to causing vision loss, myopia is also prone to complications such as dry eyes, dizziness, acidity and fatigue, which seriously affects students' learning and life (Y. Fan et al., 2018). The academic performance of uncorrected myopia relative to myopia-corrected students is a complex area of research. Data from a cluster randomized clinical trial in China showed that having children with uncorrected myopia wear eyeglasses improved their academic performance and significantly improved math scores (X. Ma et al., 2015). R. F. Zhao et al. (2008) conducted the Adaptation to Learning (AAT) survey on 316 elementary school students in the Elementary and Middle School Mental Health System, which showed that the myopic group was significantly worse than the normal control group in terms of adaptation to learning. Myopia affects adolescents' reading accuracy, and when they do read accurately, then it reduces

their reading speed (X. Ma et al., 2015). Through research data, it was found that providing eyeglasses to children with uncorrected myopia improved their academic performance (B. Holden et al., 2014). It has been found that poor vision and uncorrected vision defects in adolescents can negatively affect their academic performance and cause psychological stress, and that wearing corrective eyeglasses can improve their academic performance and mental health (Medina, 2022).

In summary, issues of myopia in adolescents such as vision impairment and uncorrected refractive errors can adversely affect their academic achievement, quality of life, mental health, and social function. If myopia is not timely intervened, due to blurred vision, the eyes will increase accommodation, resulting in prolonged excessive tension of the eye muscles, and the degree of myopia will increase. Higher degrees of myopia and longer years of myopia may lead to impaired vision, thereby impacting learning activities, quality of life, and mental health. Based on this, the following research hypotheses are put forward:

H6: The degree of myopia and years of myopia in adolescents have significant negative impacts on their quality of life, academic achievement, and mental health.

3.3 Theoretical model

3.3.1 Variable measurement

3.3.1.1 Variable measurement indicators

The socioeconomic impact of adolescent myopia may involve multiple stakeholders, namely adolescents, families, schools, hospitals, government and social organizations, and the study proposes indicators to measure the variables of each stakeholder. Among them, the indicators related to hospitals include the input of medical resources, the indicators related to the government include the input of governmental health policies and visual health, the indicators related to social organizations include the input of publicity and education for the prevention and control of myopia, the indicators related to the family include the cost of medical treatment and prescription glasses, the indicators related to adolescents include the level of their academic performance, mental health, and the quality of their lives, and the indicators related to the school include the input of materials. Based on the relevant data obtained from primary and secondary sources, we quantitatively analyze the impact of adolescent myopia on the investment in medical resources, governmental health policies and visual health, social organization's investment in myopia prevention and control publicity and education, family's medical

expenses and prescription lens expenses, adolescent's academic level, mental health, and quality of life. The variable measurement indicators are shown in Figure 3.1.

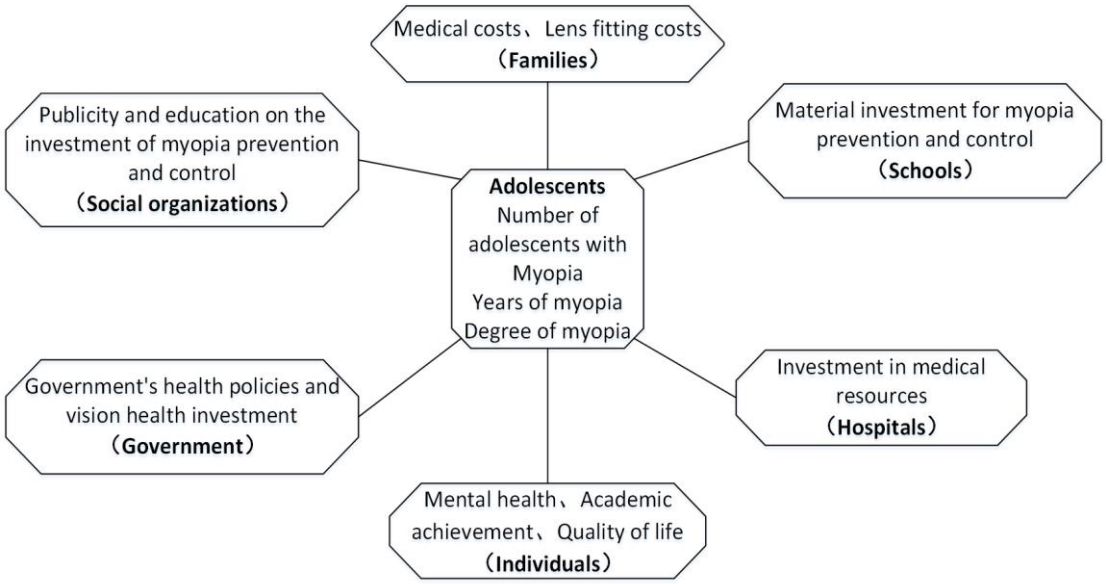

Figure 3.1 Variable measurement indicators

3.3.1.2 Definitions of variable measurement indicators and measurement methods

Based on stakeholder theory, this study clarifies the six stakeholders of adolescent myopia, the hospitals, schools, government, social organizations, families, and individuals, and proposes their variable measurement indicators and measurement methods:

1) The measurement indicators of hospital subjects are medical resource inputs, such as medical equipment costs and medical staff costs, which can be obtained through interviews with hospital staff.

2) The impact of adolescent myopia on schools can be measured through questionnaire surveys in schools and interviews with school leaders.

3) The impact of adolescent myopia on the government will be measured by health policies and vision health inputs through government document calculations and data statistics.

4) The impact of adolescent myopia on social organizations can be measured by the myopia prevention and control publicity and education of social organizations, and relevant data can be obtained through questionnaires and interviews.

5) The impact of adolescent myopia on families can be measured by the cost of medical treatment and prescription glasses.

6) The impact of myopia on individuals can be measured in terms of academic performance, mental health and quality of life. The impact of myopia on families and individual adolescents can be measured by questionnaires for parents and adolescents. The details are shown in Table

3.1 below.

Table 3.1 Definitions of variable measurement indicators and measurement methods

Stakeholder	Variable measurement indicators	Definition	Measurement method
Hospital	Investment in medical resources	It refers to the collection of costs incurred by the hospitals for providing free checkups, diagnosis, and medical expenses such as free glasses against myopia in adolescents, as well as the hospitals' expenses for the training of medical staff, education on eye health for adolescents, supervision of adolescents with myopia, and other related expenses.	The impact of increasing myopia in adolescents on the investment in medical resources was measured through interviews conducted to obtain the costs of hospitals' investment in medical equipment and staff.
School	Material investment	It refers to the schools' investment in educational equipment, healthy and compliant stationery, eye-care teaching materials, and other resources provided for myopia prevention and control.	The impact of myopia in adolescents on schools was measured and assessed through material investment by questionnaires and interviews through school material lists, material utilization records, and student satisfaction.
Government	Government's health policies and vision health investment	It refers to the government's planning and policies for the prevention and control of myopia in adolescents, with resource investment reflected in purchasing tables, chairs, and eye protection lights for adolescents.	Government policies and the extent of investment in the prevention and control of myopia in adolescents were measured and assessed through government documents, data statistics, and expert research.
Social organization	Publicity and education on myopia prevention and control	It refers to the publicity and education activities conducted by social organizations, non-profit organizations, and the media, aiming to enhance the public's awareness and attention toward the prevention and control of myopia in adolescents.	The impact of myopia in adolescents on the publicity and education on myopia prevention and control of social organizations was measured and assessed through methods such as questionnaires on social organizations, participation recording, and interviews for publicity effectiveness

			evaluation.
Family	Medical expenses and lens fitting cost	It refers to the total expenses incurred by families in the process of diagnosis, treatment, and prevention of myopia in adolescents, including expenses such as outpatient consultation fees, optometry and lens fitting costs, drug and healthcare costs, as well as transportation, accommodation, and meal expenses for adolescents with myopia and their accompanying caregivers.	The impact was measured through questionnaires on families' consumption data, medical expense reimbursement data, and families' economic status, such as "the cost of wearing spectacles or orthokeratology lens," "the number of visits and the cost of each check-up," and "transportation costs to and from hospitals or opticians."
Individual	Academic achievement	It refers to the academic performance and achievements of adolescents.	It was measured through students' learning records, subject achievements, or questionnaires. One example is "What do you think is the impact of myopia on your academic performance?"
	Mental health	It refers to the state of adolescents in terms of psychological burden, emotions, and self-confidence.	The impact of myopia in adolescents on mental health was measured and assessed through psychological assessment tools, questionnaires, and medical records, for example, "how many days in the past week did you feel depressed?"
	Quality of life	It refers to the impact of myopia on the daily life, work, learning, and social activities of adolescents.	The impact was assessed through life satisfaction questionnaires and quality of life assessment scales, for example, "What do you think is the impact of myopia on your social activities?"

3.3.2 Model building

Based on the above analysis, we believe that the problem of adolescent myopia will involve multiple stakeholders. This study clarifies the stakeholders related to the problem of adolescent myopia from the social, family and individual levels, and quantitatively analyzes the social and economic impact brought by adolescent myopia. The variable relationship model diagram is shown in Figure 3.2.

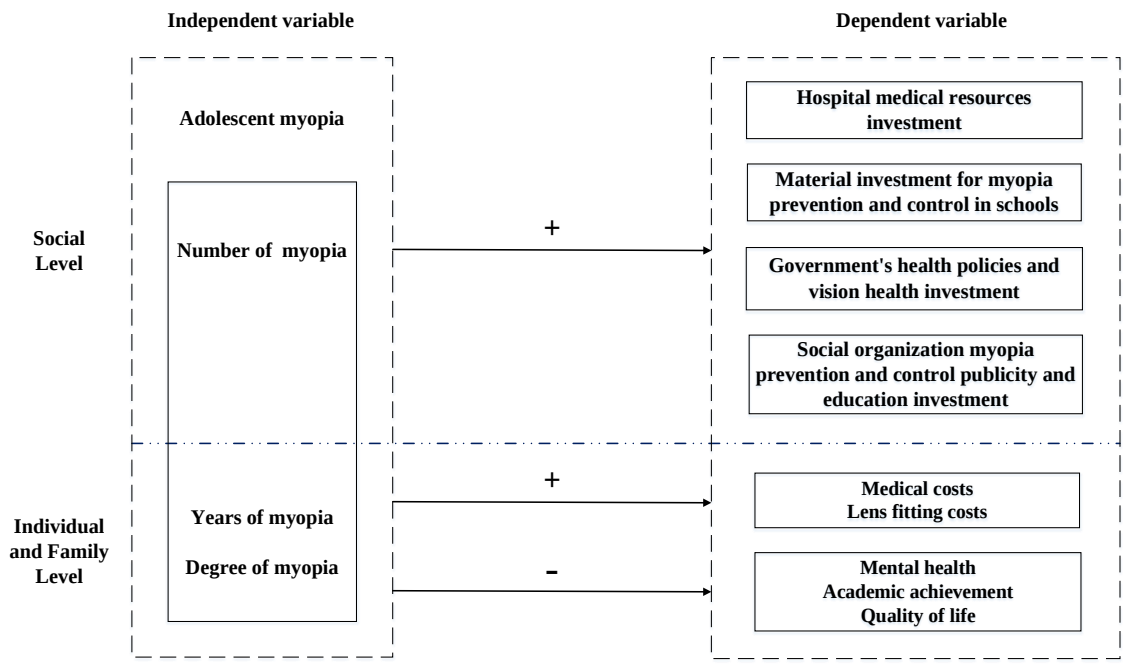

Figure 3.2 Variable relationship model diagram

At the social level, empirical analysis was conducted to verify the comprehensive impact of the number of myopia cases among adolescents on the input of medical resources in hospitals, the input of myopic prevention and control materials in primary and secondary schools, the government's health policy and visual health input, and the input of social organizations in myopic prevention and control publicity. In this study, Granger causality test was adopted to further quantitatively explore the lag period of relevant social impact, that is, the change in the number of myopias among adolescents. How many years will it take before can observe noticeable changes in various areas, such as hospital medical resources investment, primary and secondary school myopia prevention and control materials investment, government health policy and health investment, social organizations myopia prevention and control publicity and education investment?

At the individual and family level, the effects of myopia degree and years on academic achievement, mental health and quality of life of adolescents have been empirically analyzed in depth. We firmly believe that, as the degree of myopia and the number of years spent with myopia increase, the academic achievement and life quality of adolescents will be reduced, potentially giving rise to mental health issues such as stress and anxiety. Furthermore, the increase of myopia degree and myopia years will lead to a surge in family medical expenses and optician costs, posing additional financial burdens on families.

Chapter 4: Methodology

4.1 Operability

This study employs a research methodology based on empirical research. Data analysis combines qualitative and quantitative statistical methods in order to explore the socioeconomic impact of myopia in adolescents in Dalian.

4.1.1 Granger causality test

With Eviews software, the Granger causality test methodology is utilized in to elucidate the socioeconomic impact of myopia in adolescents across various levels, including hospitals, schools, government, and social organizations. The Granger causality test is not only used to test the long-term stable causality between variables but also has statistical predictability, providing good predictions of future trends in variables. Since the Granger causality test can reflect the long-term and stable relationship between variables, it is conducive to quantitative analysis of the social and economic impact on hospitals, governments and social organizations brought about by adolescent myopia.

After Granger introduced this prediction-based causality, it was gradually refined by James Simons and widely accepted and applied by economists (Hamilton, 1994). Hurlin and Venet (2003) made significant theoretical contributions in areas such as the fixed coefficient model, further maturing the theoretical framework of the Granger causality test. The principle of the Granger causality test is to determine whether the inclusion of the lag period value of X can significantly improve the prediction of Y when regressing Y on other variables (including its past values). If so, X is considered a Granger cause of Y. Conversely, Y can be defined as a Granger cause of X. The prerequisite for the Granger causality test is that the time sequences of X and Y are stationary. Otherwise, differencing of the original sequences is required. If the time sequences x_t and y_t of variables X and Y are both stationary, a lag model of y_t to y and x is established.

$$y_t = c + \sum_{i=1}^{n} \alpha_i y_{t-i} + \sum_{i=1}^{n} \beta_i x_{t-i} \tag{4.1}$$

Where c represents the constant term, and n represents the lag period. Testing whether the

change in X is a cause of the change in Y is equivalent to performing an F-test against the null hypothesis H_0: $\beta_1 = \beta_2 = ... = \beta_n = 0$, i.e., verifying that the lag term does not belong to this regression equation. The F-statistic value follows a standard F-distribution. If the F-test value is larger than the critical value of the standard F-distribution, the null hypothesis is rejected, indicating that the change in X is a Granger cause of the change in Y. Otherwise, the null hypothesis is accepted, indicating that the change in X is not a Granger cause of the change in Y. Since the Granger causality test can reflect the long-term and stable relationship between variables, it is conducive to quantitatively analyzing the dynamic relationship between the socioeconomic impact of myopia in adolescents at the family and individual levels when applied to time series data.

4.1.2 Regression analysis

The data collected from the questionnaire were empirically analyzed using SPSS software, and since the questionnaire's settings related to socioeconomic impacts were all ordered categorical variables, ordered logistic regression analysis was used to reveal the impacts of adolescent myopia on the family and individual levels. Ordered logistic regression analysis is applicable when the dependent variable is an ordered categorical variable, and the independent variables can include both continuous and categorical variables. In addition, the chi-square test was used for the analysis of differences in categorical variables.

4.2 Study sample and data collection

4.2.1 Study sample

Given the vast amount of data on myopia in adolescents in China, it is necessary to select a specific city for the study to avoid data overflow during the calculation process. In choosing the study sample, certain criteria should be met. Firstly, the selected city should be representative and able to reflect the prevalent developmental characteristics of contemporary China. Secondly, the city should have accumulated sufficient data on myopia in adolescents and related factors to provide an adequate study sample. Thirdly, the relevant data should be publicly accessible, allowing for easy access to databases and facilitating in-depth field research to obtain the necessary data for statistical analysis.

According to the above sample selection conditions, Dalian is selected as the research sample to carry out the research. Dalian is the main second-tier city in China at present, which

can reflect the general development characteristics of Chinese cities. In recent years, Dalian Municipal government, hospitals, colleges and universities and other relevant departments attach great importance to the prevention and control of myopia in adolescents, provide support in policy formulation and funding investment, and accumulate enough sample data needed for research. Moreover, the data information of nearsighted teenagers in Dalian is highly open to the outside world, and the information needed for research can be obtained from the database. To sum up, Dalian City is selected as the research sample.

4.2.2 Data sources

The data sources for all stakeholders consist of three main categories: publicly accessible data, data obtained from interviewees, and data gathered through questionnaires.

4.2.2.1 Publicly accessible data from relevant hospitals, government, and social organizations and sources

Data on the investment of hospitals in medical resources, the government's health policies and vision health investment, and the investment in publicity and education on myopia prevention and control originate from the *Annual Report on Health Resource Statistics（National Health Commission of the PRC）* was collected. This report includes information on various types of hospitals at all grades, primary medical and health institutions, specialized public health institutions, and other medical and health institutions, as well as hospital grades. It also covers the number of hospitals, township/town health centers, and community health service centers grouped by bed capacity, total health expenditures, assets and liabilities of medical and health institutions, annual income and expenditures, and average medical expenses per outpatient and inpatient. The relevant data are converted in accordance with the proportion of gross domestic product. The number of adolescents with myopia from the monitoring data of the National Disease Control and Prevention Administration and the White Paper on Vision Health of Children and Adolescents in China. The specific data are shown in Table 4.1.

Table 4.1 Publicly accessible data of relevant hospitals, government, and social organizations

Year	Number of adolescents with myopia (10,000 persons)	Hospitals' investment in medical resources (RMB 10,000)	Government's health policies and vision health investment (RMB 10,000)	Expenditure on myopia prevention and control publicity and education by social organizations (100 million

				yuan)
2010	15.7	2879	561400	77.86
2011	16.1	3490	609500	93.55
2012	17.6	4424	699000	109.46
2013	19.9	5631	745000	133.05
2014	20.6	7261	816100	157.73
2015	21.2	8483	849100	173.44
2016	22.3	9694	886500	176.71
2017	23.9	11691	962600	195.15
2018	24.3	14817	999700	204.05
2019	24.5	21220	1060500	219.22
2020	25.4	15230	1251900	222.83
2021	25.6	17949	1311200	253.05
2022	24.8	20494	1398300	265.18

Source: China Statistical Publishing House (2023)

4.2.2.2 Relevant interview data from primary and secondary schools and sources

With the assistance of the Dalian Municipal Education Bureau and its subordinate education bureaus, the above data were obtained through interviews in relevant primary and secondary schools in Dalian. The data focuses on issues such as "the investment in myopia prevention and control materials in schools" "the total material value invested in myopia prevention and control" "the maintenance, care, and cost of myopia prevention and control equipment" as well as "the expected investment for the planned introduction of new equipment and materials for myopia prevention and control".

There are 190 primary schools, 67 junior middle schools and 42 senior high schools in Dalian City. Stratified sampling method was adopted in this study, and 19 primary schools, 7 junior middle schools and 4 senior high schools were randomly selected from each tier for interview according to the proportion of each tier. This method can effectively reduce sampling error, improve sampling accuracy, and make the population more representative without increasing the total sample size. It is not only conducive to understanding the characteristics of each layer in the population, but also can select some layers for separate or comparative study. The specific data are shown in Table 4.2.

Table 4.2 Relevant interview data from primary and secondary schools

Year	Investment in myopia prevention and control materials in primary and secondary schools (RMB 10,000)
2010	208
2011	256
2012	300
2013	389
2014	498
2015	602
2016	726
2017	811

2018	937
2019	1016
2020	951
2021	1135
2022	1289

4.2.2.3 Relevant interview data from primary and secondary schools and sources

The questionnaire used in this study was self-designed. After consulting with ophthalmology experts and management personnel of relevant departments and two rounds of review and modification, it was randomly distributed according to grade level in 19 primary schools, 7 junior middle schools and 4 senior high schools in Dalian. The questionnaire was filled out by both the students and their parents. A total of 410 questionnaires were distributed and 401 questionnaires were collected. Because some of the recovered questionnaires had information misunderstanding errors, clerical errors or labeling errors, the number of valid questionnaires was 345, and the effective questionnaire recovery rate was 86.03%. The data of specific demographic variables of the samples are as follows in Table 4.3.

Table 4.3 Questionnaire samples of adolescent individuals with myopia and families

Type	Category	Frequency	Percentage	Cumulative percentage
Gender	Male	180	52.2%	52.2%
	Female	165	47.8%	100%
Age	6-12 years old	105	30.4%	30.4%
	13-15 years old	153	44.3%	74.8%
	16-18 years old	87	25.2%	100%
Educational background	Primary schools	102	29.6%	29.6%
	Junior high schools	152	44.1%	73.6%
	Senior high schools	91	26.4%	100%

4.3 Data analysis

4.3.1 Data analysis at levels of the hospitals, schools, government, and social organizations

4.3.1.1 Unit root test

Since the prerequisite for the Granger causality test is that the two sequences are stationary, it is necessary to conduct a stationarity test on them, or there will be a "spurious regression." If the original sequences are not stationary, they should be differenced until they become

stationary sequences. If the original sequences are differenced d times before becoming stationary sequences, then these sequences are called d-order integrated and denoted as $I(d)$. Taking natural logarithms of variables does not change the nature and interrelationship of time sequences and it can also eliminate possible heteroscedasticity.

Therefore, the number of adolescents with myopia in Dalian (Q), the hospitals' investment in medical resources (H), the investment in myopia prevention and control materials in primary and secondary schools (S), the government's health policies and vision health investment (G), and the social organizations' investment in publicity and education on myopia prevention and control (C) were logarithmically processed. The natural logarithms lnQ, lnS, lnH, lnG, and lnC were used for subsequent tests. The results of unit root tests are shown in Table 4.4.

Table 4.4 Unit root test

Variable	*ADF* test value	Test type	Critical value 1%	Critical value 5%	Critical value 10%	Conclusion
lnQ	-4.874	(c,0,1)	-4.297***	-3.213**	-2.748*	Stationary
lnH	-3.557	(c,0,1)	-4.421***	-3.260**	-2.771*	Stationary
lnS	-2.560	(c,0,1)	-4.122	-3.145	-2.714	Non-stationary
lnG	-5.017	(c,0,1)	-5.125***	-3.933**	-3.420*	Stationary
lnC	-4.012	(c,0,1)	-4.122***	-3.145**	-2.714*	Stationary
ΔlnS	-3.235	(c,0,1)	-5.295	-4.008	-3.461	Non-stationary
$\Delta^2 lnS$	-4.862	(c,0,1)	-2.817***	-1.982**	-1.601*	Stationary

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The results of the ADF unit root test show that the original sequence (lnQ) of the number of adolescents with myopia, the original sequence (lnH) of the hospitals' investment in medical resources, the original sequence (lnG) of the government's health policies and vision health investment, and the original sequence (lnC) of the social organizations' investment in publicity and education on myopia prevention and control are stationary sequences. The investment in myopia prevention and control materials in primary and secondary schools (lnS) is a non-stationary sequence.

Therefore, it requires differencing, and the results show that the second-order difference sequence ($\Delta^2 lnS$) of the investment in myopia prevention and control materials in primary and secondary schools is significant at the significance level of 1%, indicating it is a stationary sequence. Consequently, the original sequence of the number of adolescents with myopia (lnQ), the original sequence of hospitals' investment in medical resources (lnH), the original sequence of the government's health policies and vision health investment (lnG), and the

original sequence of social organizations' investment in publicity and education on myopia prevention and control (lnC) are all zero-order integrated, while the original sequence of the investment in myopia prevention and control materials in primary schools (lnS) is second-order integrated, namely, $lnQ\sim I(0)$, $lnH\sim I(0)$, $lnS\sim I(2)$, $lnG\sim I(0)$, $lnC\sim I(0)$, which satisfy the necessary conditions for subsequent tests.

4.3.1.2 Cointegration test

(1) Number of adolescents with myopia and hospitals' investment in medical resources

To test the causality between the number of adolescents with myopia and the hospitals' investment in medical resources, it is necessary to first prove that there is a long-term dynamic equilibrium relationship between the above variables. Cointegration reflects a long-term dynamic equilibrium relationship between non-stationary integrated sequences, that is, the linear combination of two non-stationary time sequences offsets the influence of trend terms, making the combination a stationary time sequence. Cointegration analysis was adopted in this study to test the long-term dynamic equilibrium relationship between the number of adolescents with myopia and the hospitals' investment in medical resources.

According to the Engle-Granger two-step test method, the cointegration relationship between the number of adolescents with myopia and the hospitals' investment in medical resources was tested. With this method, it is first required to estimate the cointegration regression equation of the variables and generate the residual accordingly. Then, the stationarity of the residual sequence is tested. If the residual sequence is stationary, it indicates that there is a cointegration relationship between the variables, and vice versa. Therefore, the least square method (OLS) was first used to estimate the cointegration regression equation of lnH and lnQ.

$$\boldsymbol{lnH_t=-2.468+0.086t+1.975\,lnQ_t} \qquad (4.2)$$

(1.336) (2.924**) (2.966**) R^2= 0.971

The analysis results show that the t-statistic and lnQ t-statistic are significant at the significance level of 5%, and the goodness of fit of the model is high. This indicates that the hospitals' investment in medical resources in the t-th year is not only related to the year of investment but also the number of adolescents with myopia. Based on the cointegration regression equation, the residual term is generated by shifting terms to facilitate the unit root test.

$$\textbf{Residual term } \boldsymbol{e_t=lnH_t+2.468-0.086t-1.975\,lnQ_t} \qquad (4.3)$$

By testing the stationarity of the residual sequence (e), the cointegration relationship between lnH and lnQ can be determined, that is, whether there is a long-term stable equilibrium relationship between the hospitals' investment in medical resources and the number of adolescents with myopia. The specific data are shown in Table 4.5.

Table 4.5 Residual unit root test

Variable	*ADF* test value	Test type	Critical value 1%	Critical value 5%	Critical value 10%	Conclusion
Residual (e_t)	-3.861	(0,0,0)	-2.792***	-1.978**	-1.602*	Stationary

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The cointegration analysis requires that the statistics are significant at a significance level of at least 10%. The results of the ADF unit root test show that the residual sequence (e_t) is significant at a significance level of 5%. Therefore, the residual sequence (e_t) is stationary. This indicates that there is a cointegration relationship between lnH and lnQ, implying a long-term stable dynamic equilibrium relationship between the hospitals' investment in medical resources and the number of adolescents with myopia.

(2) Number of adolescents with myopia and investment in myopia prevention and control materials in primary and secondary schools

To test the causality between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools, it is necessary to first prove that there is a long-term dynamic equilibrium relationship between the above variables. Cointegration reflects a long-term dynamic equilibrium relationship between non-stationary integrated sequences, that is, the linear combination of two non-stationary time sequences offsets the influence of trend terms, making the combination a stationary time sequence. Cointegration analysis was adopted in this study to test the long-term dynamic equilibrium relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools.

According to the Engle-Granger two-step test method, the cointegration relationship between the number of adolescents with myopia in Dalian and the investment in myopia prevention and control materials in primary and secondary schools was tested. With this method, it is first required to estimate the cointegration regression equation of the variables and generate the residual accordingly. Then, the stationarity of the residual sequence is tested. If the residual sequence is stationary, it indicates that there is a cointegration relationship between the variables, and vice versa. Therefore, the least square method (OLS) was first used to estimate the cointegration regression equation of lnH and lnQ.

$$\ln S_t = -0.276 + 0.066t + 2.029 \ln Q_t \quad (4.4)$$

(-0.227) (3.412***) (4.626***) $R^2 = 0.984$

The analysis results show that the t-statistic and $\ln Q_t$-statistic are significant at the significance level of 1%, and the goodness of fit of the model is high. This indicates that the investment in myopia prevention and control materials in primary and secondary schools in the t-th year is not only related to the year of investment but also the number of adolescents with myopia. Based on the cointegration regression equation, the residual term is generated by shifting terms to facilitate the unit root test.

$$\text{Residual term } e_t = \ln S_t + 0.277 - 0.066t + 2.029 \ln Q_t \quad (4.5)$$

By testing the stationarity of the residual sequence (e), the cointegration relationship between $\ln S$ and $\ln Q$ can be determined, that is, whether there is a long-term stable equilibrium relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools. If the residual sequence (e) is stationary, it indicates that there is a cointegration relationship between $\ln S$ and $\ln Q$, and vice versa. The specific data are shown in Table 4.6.

Table 4.6 Residual unit root test

Variable	*ADF* test value	Test type	Critical value 1%	Critical value 5%	Critical value 10%	Conclusion
Residual (e_t)	-3.099	(0,0,0)	-2.792***	-1.978**	-1.602*	Stationary

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The cointegration analysis requires that the statistics are significant at a significance level of at least 10%. The analysis results of the ADF unit root test show that the residual sequence (e_t) is significant at a significance level of 1%. Therefore, the residual sequence (e_t) is stationary. This indicates that there is a cointegration relationship between $\ln S$ and $\ln Q$, implying a long-term stable dynamic equilibrium relationship between the investment in myopia prevention and control materials in primary and secondary schools and the number of adolescents with myopia.

(3) Number of adolescents with myopia and government's health policies and vision health investment

To test the causality between the number of adolescents with myopia and the government's health policies and vision health investment, it is indispensable to prove that there is a long-term dynamic equilibrium relationship between the above variables at first. Cointegration reflects a long-term dynamic equilibrium relationship between non-stationary integrated

sequences, that is, the linear combination of two non-stationary time sequences offsets the influence of trend terms, making the combination a stationary time sequence. Cointegration analysis was adopted in this study to test the long-term dynamic equilibrium relationship between the number of adolescents with myopia and the government's health policies and vision health investment.

According to the Engle-Granger two-step test method, the cointegration relationship between the number of adolescents with myopia in Dalian and the government's health policies and vision health investment was tested. With this method, it is first required to estimate the cointegration regression equation of the variables and generate the residual accordingly. Then, the stationarity of the residual sequence is tested. If the residual sequence is stationary, it indicates that there is a cointegration relationship between the variables, and vice versa. Therefore, the least square method (OLS) was first used to estimate the cointegration regression equation of lnG and lnQ.

$$lnG_t=3.183+0.221t+3.321\,lnQ_t \quad (4.6)$$

$$(0.719)\ (2.966^{**})\ (2.303^{**}) \qquad R^2=0.625$$

The analysis results show that the t-statistic and lnQ_t-statistic are significant at the significance levels of 5% and 1, respectively, and the goodness of fit of the model is high. This indicates that the government's health policies and vision health investment in the t-th year is not only related to the year of investment but also the number of adolescents with myopia. Based on the cointegration regression equation, the residual term is generated by shifting terms to facilitate the unit root test.

$$\text{Residual term } e_t=lnG_t-3.183-0.221t-3.321\,lnQ_t \quad (4.7)$$

By testing the stationarity of the residual sequence (e), the cointegration relationship between lnG and lnQ can be determined, that is, whether there is a long-term stable equilibrium relationship between the government's health policies and vision health investment and the number of adolescents with myopia. The results of residual unit root test are shown in Table 4.7.

Table 4.7 Residual unit root test

Variable	*ADF* test value	Test type	Critical value 1%	Critical value 5%	Critical value 10%	Conclusion
Residual (e_t)	-4.433	(0,0,0)	-2.792***	-1.978**	-1.602*	Stationary

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The cointegration analysis requires that the statistics are significant at a significance level

of at least 10%. The results of the ADF unit root test show that the residual sequence (e_t) is significant at a significance level of 1%. Therefore, the residual sequence (e_t) is stationary. This indicates that there is a cointegration relationship between lnG and lnQ, implying a long-term stable dynamic equilibrium relationship between the government's health policies and vision health investment and the number of adolescents with myopia.

(4) Number of adolescents with myopia and social organizations' investment in publicity and education on myopia prevention and control

To test the causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control, it is indispensable to determine that there is a long-term dynamic equilibrium relationship between the above variables at first. Cointegration reflects a long-term dynamic equilibrium relationship between non-stationary integrated sequences, that is, the linear combination of two non-stationary time sequences offsets the influence of trend terms, making the combination a stationary time sequence. The analysis of cointegration was adopted in this study to test the long-term dynamic equilibrium relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control.

According to the Engle-Granger two-step test method, the cointegration relationship between the number of adolescents with myopia in Dalian and the social organizations' investment in publicity and education on myopia prevention and control was tested. With this method, it is first necessary to estimate the cointegration regression equation for the relevant variables and then generate the corresponding residuals based on that estimation. Then, the stationarity of the residual sequence is tested. If the residual sequence is stationary, it indicates that there is a cointegration relationship between the variables, and vice versa. Therefore, the least square method (*OLS*) was first used to estimate the cointegration regression equation of lnC and lnQ.

$$\boldsymbol{lnC_t=0.328+0.033t+1.484\,lnQ_t} \qquad (4.8)$$

$$(0.362)\ (2.296^{**})\ (4.540^{***}) \qquad R^2=0.978$$

The analysis results show that the intercept term, *t*-statistic, and $ln\,Q_t$-statistic are significant at the significance level of 1%, and the goodness of fit of the model is high. This indicates that the social organizations' investment in publicity and education on myopia prevention and control in the *t*-th year is not only related to the year of investment but also the number of adolescents with myopia. Based on the cointegration regression equation, the

residual term is generated by shifting terms to facilitate the unit root test.

$$\textbf{Residual term } e_t = lnC_t - 0.238 - 0.033t - 1.484\, lnQ_t \quad (4.9)$$

By testing the stationarity of the residual sequence (e), the cointegration relationship between lnC and lnQ can be determined, that is, whether there is a long-term stable equilibrium relationship between the social organizations' investment in publicity and education on myopia prevention and control and the number of adolescents with myopia. The specific data are shown in Table 4.8.

Table 4.8 Residual unit root test

Variable	*ADF* test value	Test type	Critical value 1%	Critical value 5%	Conclusion
Residual (*e1*)	-2.777	(0,0,0)	-2.772***	-1.974**	Stationary

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The cointegration analysis requires that the statistics are significant at a significance level of at least 10%. The results of the ADF unit root test show that the residual sequence (e_t) is significant at a significance level of 1%. Therefore, the residual sequence (e_t) is stationary. This indicates that there is a cointegration relationship between lnC and lnQ, implying a long-term stable dynamic equilibrium relationship between the social organizations' investment in publicity and education on myopia prevention and control and the number of adolescents with myopia.

4.3.1.3 Error correction model

(1) Number of adolescents with myopia and hospitals' investment in medical resources

The cointegration analysis reflects a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the hospitals' investment in medical resources. However, under normal conditions, the relationship between variables may deviate from the equilibrium point, indicating the existence of a short-term equilibrium or non-equilibrium relationship. If such deviation is temporary, then over time, the inherent equilibrium mechanism will prompt the system to return to a state of equilibrium. Therefore, on the basis of the cointegration analysis, an error correction model including an error correction term was built to study the short-term dynamics and long-term adjustment characteristics of the model.

$$\Delta lnH = 0.418\Delta lnH_{t-1} - 0.682\Delta lnQ_t + 2.513\Delta lnQ_{t-1} - 1.429e_{t-1} \quad (4.10)$$

$$(1.689^*) \quad (-0.669) \quad (2.561^{**}) \quad (-3.474^{***}) \quad R^2 = 0.667$$

The results show that the statistics of ΔlnH_{t-1}, ΔlnQ_{t-1}, and e_{t-1} are significant at the significance levels of 10%, 5%, and 1%, respectively, meeting the minimum requirement of

significance at the significance level of 10%. This indicates that in the short term, changes in the hospitals' investment in medical resources are impacted by the degree of disequilibrium in the previous period, indicating the existence of a short-term correction effect between the long-term equilibrium of the hospitals' investment in medical resources and the number of adolescents with myopia. When it deviates from the long-term equilibrium due to short-term fluctuations, there will be a certain degree of adjustment to return the disequilibrium to equilibrium.

(2) Number of adolescents with myopia and investment in myopia prevention and control materials in primary and high schools

The cointegration analysis reflects a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools. However, under normal conditions, the relationship between variables may deviate from the equilibrium point, indicating the existence of a short-term equilibrium or disequilibrium relationship. If such deviation is temporary, then over time, the inherent equilibrium mechanism will prompt the system to return to equilibrium. Therefore, on the basis of the cointegration analysis, an error correction model including an error correction term was built to study the short-term dynamics and long-term adjustment characteristics of the model.

$$\Delta \ln S = 0.615\Delta \ln S_{t-1} - 0.579\Delta \ln Q_t + 1.645\Delta \ln Q_{t-1} - 1.052e_{t-1} \quad (4.11)$$

(2.913***) (-0.989) (2.896**) (-2.435**) R^2=0.662

The results show that the statistics of $\Delta \ln S_{t-1}$, $\Delta \ln Q_{t-1}$, and e_{t-1} are significant at the significance levels of 1%, 5%, and 5%, respectively, meeting the minimum requirement of significance at the significance level of 10%. This indicates that in the short term, changes in the investment in myopia prevention and control materials in primary and secondary schools are impacted by the degree of disequilibrium in the previous period, indicating the existence of a short-term correction effect between the investment in myopia prevention and control materials in primary and secondary schools and the number of adolescents with myopia. When it deviates from the long-term equilibrium due to short-term fluctuations, there will be a certain degree of adjustment to return the disequilibrium to equilibrium.

(3) Number of adolescents with myopia and government's health policies and vision health investment

The cointegration analysis reflects a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the government's health policies and vision

health investment. Nevertheless, under normal conditions, the relationship between variables may deviate from the equilibrium point, indicating the existence of a short-term equilibrium or non-equilibrium relationship. If such deviation is temporary, then over time, the inherent equilibrium mechanism will prompt the system to return to a state of equilibrium. Therefore, on the basis of the cointegration analysis, an error correction model including an error correction term was built to study the short-term dynamics and long-term adjustment characteristics of the model.

$$\Delta lnG = 0.291\Delta lnG_{t-1} - 11.043\Delta lnQ_t - 10.525\Delta lnQ_{t-1} - 0.830e_{t-1} \quad (4.12)$$

(1.022) (-1.993*) (-1.677) (-2.060*) R^2=0.763

The results show that the statistics of $\Delta \ln Q_{t-1}$ and e_{t-1} are significant at the significance levels of 10% and 10%, respectively, meeting the minimum requirement of significance at the significance level of 10%. This indicates that in the short term, changes in the government's health policies and vision health investment are impacted by the degree of disequilibrium in the previous period, indicating the existence of a short-term correction effect between the long-term equilibrium of the government's health policies and vision health investment and the number of adolescents with myopia. When it deviates from the long-term equilibrium due to short-term fluctuations, there will be a certain degree of adjustment to return the disequilibrium to equilibrium.

(4) Number of adolescents with myopia and investment in publicity and education on myopia prevention and control by social organizations

The cointegration analysis reflected a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control. However, under normal conditions, the relationship between variables may deviate from the equilibrium point, indicating the existence of a short-term equilibrium or non-equilibrium relationship. If such deviation is temporary, then over time, the inherent equilibrium mechanism will prompt the system to return to a state of equilibrium. Therefore, on the basis of the cointegration analysis, an error correction model including an error correction term was built to study the short-term dynamics and long-term adjustment characteristics of the model.

$$\Delta lnC = 0.486\Delta lnC_{t-1} + 0.203\Delta lnQ_t + 0.760\Delta lnQ_{t-1} - 0.875e_{t-1} \quad (4.13)$$

(2.261**) (0.520) (1.836*) (-1.850*) R^2=0.673

The results showed that the statistics of ΔlnC_{t-1}, ΔlnQ_{t-1}, and e_{t-1} were significant at the significance levels of 5%, 10%, and 10%, respectively, meeting the minimum requirement of

significance at the significance level of 10%. This indicated that in the short term, changes in the social organizations' investment in publicity and education on myopia prevention and control were impacted by the degree of disequilibrium in the previous period, indicating the existence of a short-term correction effect between the social organizations' investment in publicity and education on myopia prevention and control and the number of adolescents with myopia. When it deviated from the long-term equilibrium due to short-term fluctuations, there would be a certain degree of adjustment to return the disequilibrium to equilibrium.

4.3.1.4 Granger causality test

(1) Number of adolescents with myopia and hospitals' investment in medical resources

The results of the cointegration analysis indicated that there existed a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the hospitals' investment in medical resources, but whether this relationship constituted causality required further verification. Therefore, the Granger causality test was adopted to further examine whether there is a causal relationship between the above variables. To test the causality between variables, it is crucial to take into account the lag period. As the time sequence used in this study was annual data, the lag period was measured in years as well. The analytical software Eviews13.0 suggested an optimal lag period of 3 years based on the length of the time sequence. However, for the sake of caution, a Granger causality test was conducted for each lag period from 1 to 3 years to clarify the interaction between variables. The specific data are shown in Table 4.9.

Table 4.9 Granger causality test

Null hypothesis	Lag period	*F*-value	*P*-value	Conclusion
lnQ is not the Granger cause of lnH	1	9.596	0.013**	Rejected
lnQ is not the Granger cause of lnH	2	3.390	0.104	Accepted
lnQ is not the Granger cause of lnH	3	0.911	0.530	Accepted

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The results showed that there was Granger causality between the number of adolescents with myopia and the hospitals' investment in medical resources. Regarding the null hypothesis that "lnQ is not a Granger cause of lnH," when the lag period was 1 year, the result was significant at the significance level of 5%, and the null hypothesis was rejected. This indicated that the changes in the number of teenagers with myopia in the earlier period could explain the

future situation of the hospitals' investment in medical resources, and the number of adolescents with myopia was a Granger cause of the hospitals' investment in medical resources. This suggested that the number of adolescents with myopia had a significant promoting effect on the hospitals' investment in medical resources, and an increase in the former would lead to an increase in the latter in the future.

(2) Number of adolescents with myopia and investment in myopia prevention and control materials in primary and secondary schools

The results of the cointegration analysis indicate that there exists a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in schools, but whether this relationship constitutes causality requires further verification. Therefore, the Granger causality test is adopted to further examine whether there is a causal relationship between the above variables. To test the causality between variables, it is crucial to take into account the lag period. As the time sequence used in this study was annual data, the lag period was measured in years as well. The analytical software Eviews13.0 suggested an optimal lag period of 3 years based on the length of the time sequence. However, for the sake of caution, a Granger causality test was conducted for each lag period from 1 to 3 years to clarify the interaction between variables. The specific data are shown in Table 4.10.

Table 4.10 Granger causality test

Null hypothesis	Lag period	*F*-value	*P*-value	Conclusion
lnQ is not the Granger cause of lnS	1	7.270	0.025**	Rejected
lnQ is not the Granger cause of lnS	2	2.651	0.150	Accepted
lnQ is not the Granger cause of lnS	3	0.589	0.663	Accepted

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The results showed that there was Granger causality between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools. Regarding the null hypothesis that "lnQ is not a Granger cause of lnS," when the lag period was 1 year, the result was significant at the significance level of 5%, and the null hypothesis was rejected. This indicated that the changes in the number of teenagers with myopia in the earlier period could explain the future changes in the investment in myopia prevention and control materials in primary and secondary schools, and the number of

adolescents with myopia was a Granger cause of the investment in myopia prevention and control materials in primary and secondary schools. This suggested that the number of adolescents with myopia had a significant promoting effect on the investment in myopia prevention and control materials in primary and secondary schools, and an increase in the former would lead to an increase in the latter.

(3) Number of adolescents with myopia and government's health policies and vision health investment

The results of the cointegration analysis indicate that there exists a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the government's health policies and vision health investment, but whether this relationship constitutes causality requires further verification.

Therefore, the Granger causality test is adopted to further examine whether there is a causal relationship between the above variables. To test the causality between variables, it is crucial to take into account the lag period. As the time sequence used in this study was annual data, the lag period was measured in years as well. The analytical software Eviews13.0 suggested an optimal lag period of 3 years based on the length of the time sequence. However, for the sake of caution, a Granger causality test was conducted for each lag period from 1 to 3 years to clarify the interaction between variables. The specific data are shown in Table 4.11.

Table 4.11 Granger causality test

Null hypothesis	Lag period	*F*-value	*P*-value	Conclusion
lnQ is not the Granger cause of lnG	1	7.037	0.026**	Rejected
lnQ is not the Granger cause of lnG	2	26.147	0.001***	Rejected
lnQ is not the Granger cause of lnG	3	1.645	0.346	Accepted

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The results showed that there was Granger causality between the number of adolescents with myopia and the government's health policies and vision health investment. Regarding the null hypothesis that "lnQ is not a Granger cause of lnG," when the lag period was 1-2 years, the results were significant at the significance levels of 5% and 1%, respectively, and the null hypothesis was rejected. This indicated that the changes in the number of teenagers with myopia in the earlier period could explain the future changes in the government's health policies and vision health investment, and the number of adolescents with myopia was a Granger cause of

the government's health policies and vision health investment. This suggested that the number of adolescents with myopia had a significant promoting effect on the government's health policies and vision health investment, and an increase in the former would lead to an increase in the latter.

(4) Number of adolescents with myopia and social organizations' investment in publicity and education on myopia prevention and control

The results of the cointegration analysis indicate that there exists a long-term stable dynamic equilibrium relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control, but whether this relationship constitutes causality requires further verification. Therefore, the Granger causality test is adopted to further examine whether there is a causal relationship between the above variables. To test the causality between variables, it is crucial to take into account the lag period. As the time sequence used in this study was annual data, the lag period was measured in years as well. The analytical software Eviews13.0 suggested an optimal lag period of 3 years based on the length of the time sequence. However, for the sake of caution, a Granger causality test was conducted for each lag period from 1 to 3 years to clarify the interaction between variables. The specific data are shown in Table 4.12.

Table 4.12 Granger causality test

Null hypothesis	Lag period	*F*-value	*P*-value	Conclusion
lnQ is not the Granger cause of lnC	1	1.773	0.216	Accepted
lnQ is not the Granger cause of lnC	2	1.402	0.317	Accepted
lnQ is not the Granger cause of lnC	3	0.570	0.672	Accepted

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% significance levels respectively.

The results showed that there was no Granger causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control when the lag period was 1 to 3 years. Regarding the null hypothesis that "lnQ is not a Granger cause of lnG," when the lag period was 1-3 years, the result was not significant at the significance level of 10%, and the null hypothesis was accepted. However, it is also possible to be significant within a longer lag period due to the limited availability of relevant data before 2010, so only time sequence data in 13 years from 2010 to 2022 were extracted, with a lag period of only three years. The response time of myopia in adolescents to

the social organizations' investment in publicity and education on myopia prevention and control is longer compared to hospital and school entities that are closely related to myopia. The lag period may be even longer, and it is anticipated that there will be a Granger causality between the two over a longer lag period.

4.3.2 Data analysis at levels of individuals and families

4.3.2.1 Descriptive statistics

Descriptive statistics were carried out based on the recovered questionnaire data. Among them, items such as age, gender, educational background, degree of myopia, mental health, quality of life, academic level, medical expenses and lens fitting expenses were set as ordered categorical variables, and items such as myopia years were set as continuous variables. For details, see Appendix A for the questionnaire.

The descriptive statistical results showed that the average of myopia years is 3.51, the standard deviation is 2.312, and the variance is 5.343, the average of myopia degree is 1.37, the standard deviation is 0.541, and the variance is 0.292, the average of mental health is 1.78, the standard deviation is 0.798, and the variance is 0.637, and the average of quality of life is 3.68, with a standard deviation of 1.490, and the variance is 2.219. The average of academic achievement is 3.95 with a standard deviation of 1.165 and a variance of 1.358, the average of medical expenses is 1.63 with a standard deviation of 0.807 and a variance of 0.651, and the average of lens fitting costs is 2.18 with a standard deviation of 1.389 and a variance of 1.929.

4.3.2.2 Difference analysis

(1) Gender and variable difference analysis

Since the dependent variables such as academic achievement, mental health, quality of life, medical expenses and Lens fitting costs in the questionnaire were set by sequential categorical variables, Chi-square test was used to analyze whether there were significant differences in academic achievement, mental health, quality of life, medical expenses and Lens fitting costs among myopic adolescents of different genders (male and female). The specific data are shown in Table 4.13.

Table 4.13 Gender and variable difference analysis

		Value	Df	Sig. (2-sided)
Academic achievement	Pearson Chi-square	1.709[a]	4	.789
	Likelihood Ratio	1.709	4	.789

		Value	Df	Sig. (2-sided)
Mental health	Continuity correction[b]	.349	1	.554
	Pearson Chi-square	1.825[a]	3	.610
	Likelihood Ratio	1.827	3	.609
Quality of life	Continuity correction[b]	1.593	1	.207
	Pearson Chi-square	7.585[a]	6	.270
	Likelihood Ratio	7.722	6	.259
Medical expenses	Continuity correction[b]	2.749	1	.097
	Pearson Chi-square	2.487a	5	.778
	Likelihood Ratio	3.262	5	.660
Lens fitting costs	Continuity correction[b]	.091	1	.763
	Pearson Chi-square	1.856[a]	5	.869
	Likelihood Ratio	1.870	5	.867
	Continuity correction[b]	.027	1	.869

As can be seen from the above table, there were no significant differences in in academic achievement, mental health, quality of life, medical expenses and lens fitting costs among myopic adolescents of different genders (p>0.05).

(2) Age and variable difference analysis

Since the dependent variables in the questionnaire, such as academic achievement, mental health, quality of life, medical expenses and lens fitting costs, were all set as ordinal categorical variables, the chi-square test was used to determine whether there were significant differences in mental health, quality of life, academic achievement, medical expenses and lens fitting costs among myopic adolescents of different ages (6-12 years old, 13-15 years old, 16-18 years old). The results are shown in Table 4.14.

Table 4.14 Age and variable difference analysis

		Value	Df	Sig. (2-sided)
Academic achievement	Pearson Chi-square	91.182[a]	8	.000
	Likelihood Ratio	88.621	8	.000
	Continuity correction[b]	67.106	1	.000

Mental health	Pearson Chi-square	7.833[a]	6	.251
	Likelihood Ratio	9.385	6	.153
	Continuity correction[b]	3.296	1	.069
Quality of life	Pearson Chi-square	63.444[a]	12	.000
	Likelihood Ratio	72.716	12	.000
	Continuity correction[b]	43.495	1	.000
Medical expenses	Pearson Chi-square	12.844[a]	10	.233
	Likelihood Ratio	14.439	10	.154
	Continuity correction[b]	5.677	1	.017
Lens fitting costs	Pearson Chi-square	25.331[a]	10	.005
	Likelihood Ratio	26.899	10	.003
	Continuity correction[b]	15.969	1	.000

As can be seen from the above table, there are significant differences in academic achievement, quality of life and lens fitting costs among myopic adolescents of different ages (p<0.05), while there are no significant differences in mental health and medical expenses among myopic adolescents of different ages (p>0.05).

For the above variables with inter-group differences, the rank sum test method of multi-group independent sample comparison was used to further carry out the pairwise comparison of difference items. The pairwise comparison of difference terms was extended by Kruskal and Wallis on the basis of the Wilcoxon two-sample rank sum test, also known as Kruskal-Wallish test, which is used to infer whether multiple population distributions of continuous variables or ordered categorical variables are different. The results of pairwise comparison are shown in Table 4.15.

Table 4.15 Pairwise comparison

	Sample 1 - Sample 2	Test statistics	Standard error	Standard test statistics	Sig.	Adjust sig.
Academic achievement	16-18 years - 13-15 years	71.763	12.674	5.662	.000	.000
	16-18 years - 6-12 years	115.290	13.684	8.425	.000	.000
	13-15 years -	43.527	11.961	3.639	.000	.001

	Sample 1 - Sample 2	Test statistics	Standard error	Standard test statistics	Sig.	Adjust sig.
Quality of life	6-12years 16-18 years - 13-15 years	41.318	13.117	3.150	.002	.005
	16-18 years - 6-12 years	97.394	14.163	6.877	.000	.000
	13-15 years - 6-12 years	56.076	12.380	4.530	.000	.000
Lens fitting costs	16-18 years - 13-15 years	7.442	12.677	.587	.557	1.000
	16-18 years - 6-12 years	41.010	13.687	2.996	.003	.008
	13-15 years - 6-12 years	33.568	11.964	2.806	.005	.015

The results of pairwise comparison showed that there was a significant difference between 16-18 years old and 13-15 years old (p=0.000). There was a significant difference between 16-18 years old and 6-12 years old (p=0.000) There was a significant difference between 13-15 years old and 6-12 years old (p=0.001).

The pairwise comparison analysis showed that there was a significant difference between 16-18 years old and 13-15 years old in quality of life (p=0.005); There was significant difference in quality of life between 16-18 years old and 6-12 years old (p=0.000); There was a significant difference in quality of life between 13-15 years old and 6-12 years old (p=0.000).

The results of pairwise comparison showed that there was a significant difference between the cost of opticians aged 16-18 and 6-12 (p=0.008); There was a significant difference in the cost of opticians between 13-15 years old and 6-12 years old (p=0.015). There was no significant difference between 16-18 years old and 13-15 years old.

(3) Educational background and variable difference analysis

Chi-square test was used to analyze whether there were significant differences in academic achievement, mental health, quality of life, medical expenses and Lens fitting costs among myopic adolescents with different educational background (primary school, middle school and high school). The specific data are shown in Table 4.16.

Table 4.16 Educational background and variable difference analysis

		Value	Df	Sig. (2-sided)
Academic	Pearson	72.452[a]	8	.000

		Value	Df	Sig. (2-sided)
achievement	Chi-square Likelihood Ratio	76.434	8	.000
	Continuity correction[b]	55.581	1	.000
Mental health	Pearson Chi-square	10.945[a]	6	.090
	Likelihood Ratio	12.183	6	.058
	Continuity correction[b]	8.643	1	.003
Quality of life	Pearson Chi-square	61.334[a]	12	.000
	Likelihood Ratio	66.557	12	.000
	Continuity correction[b]	41.095	1	.000
Medical expenses	Pearson Chi-square	14.334[a]	10	.158
	Likelihood Ratio	15.508	10	.115
	Continuity correction[b]	1.351	1	.245
Lens fitting costs	Pearson Chi-square	21.864[a]	10	.016
	Likelihood Ratio	24.029	10	.008
	Continuity correction[b]	18.536	1	.000

As can be seen from the above table, there are significant differences in academic achievement, quality of life and lens fitting costs among myopic adolescents with different educational background (p<0.05), while there are no significant differences in mental health and medical costs among myopic adolescents with different educational background (p>0.05). For the variables with inter-group differences, the rank sum test method of multi-group independent sample comparison was used to further compare the difference items in pairs. The specific data are shown in Table 4.17.

Table 4.17 Pairwise comparison

	Sample 1 - Sample 2	Test statistics	Standard error	Standard test statistics	Sig.	Adjust sig.
Academic achievement	High school - Middle school	53.074	12.511	4.242	.000	.000
	High school - Primary school	109.670	13.610	8.058	.000	.000
	Middle school -	56.596	12.081	4.685	.000	.000

	Sample 1 - Sample 2	Test statistics	Standard error	Standard test statistics	Sig.	Adjust sig.
Quality of life	Primary school - High school	23.496	12.948	1.815	.070	.209
	High school - Middle school	92.791	14.087	6.587	.000	.000
	Middle school - Primary school	69.294	12.504	5.542	.000	.000
Lens fitting costs	Primary school - High school	19.861	12.514	1.587	.112	.337
	High school - Middle school	50.464	13.614	3.707	.000	.001
	Middle school - Primary school	30.603	12.084	2.533	.011	.034

The pairings of educational background in academic achievement showed that there was significant difference between high school and middle school (p=0.000); There was significant difference between high school and primary school (p=0.000); There is a significant difference between junior high school and primary school (p=0.000).

The pair-to-pair comparison of educational background on quality of life shows that there was significant difference in quality of life between high school and primary school (p=0.000); There was a significant difference in quality of life between junior high school and primary school (p=0.000). There is no significant difference between high school and middle school.

The pair-to-pair comparison of educational background on lens fitting costs showed that there was significant difference between high school and primary school (p=0.001); There is a significant difference between the cost of optician in junior high school and primary school (p=0.034). There was no significant difference between high school and middle school.

4.3.2.3 Regression analysis

1) Adolescent myopia and academic achievement

With the degree of myopia and years of myopia as independent variables and the academic achievement as dependent variables, the regression model of myopia degree, years of myopia and academic achievement was constructed by using ordered logistic regression analysis. Among them, the measurement of myopia degree involves the sixth and seventh questions of the questionnaire (see Appendix A), the measurement of myopia years involves the ninth question, and the measurement of academic achievement involves the 28th question. The results

of parallel linesa and model fitting information test are shown in the Table 4.18.

Table 4.18 Test of parallel linesa and model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	260.950			
General	245.609[b]	15.341[c]	9	.082
Intercept Only	292.053			
Final	260.950	31.103	3	.000

The results of the test of parallel linesa showed that the significance p=0.082>0.05, which indicates that the regression equations are parallel to each other, it is considered that the different categories of dependent variables satisfy the assumption of parallelism and the results of the parameter estimation table are reliable.

As can be seen from the table, the significance of the model fitting degree is 0.00<0.05, which indicates that the model fits well and at least one variable in the model has statistical significance.

From the Table 4.19, it can be seen that the estimated value of the regression coefficient of the years of myopia will be -0.254, with the significance p=0.000<0.05, which is statistically significant, meaning that the years of myopia will have a significant negative impact on the academic achievement; and the estimated value of the regression coefficient of each group of the degree of myopia is more than 0.05 in terms of significance, which means that the degree of myopia does not have a significant effect on the academic achievement.

Table 4.19 Estimation of parameters

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Threshold	[Academic achievement = 1]	-4.630	.732	40.007	1	.000	-6.064	-3.195
	[Academic achievement = 2]	-3.404	.698	23.783	1	.000	-4.772	-2.036
	[Academic achievement = 3]	-2.539	.686	13.704	1	.000	-3.884	-1.195
	[Academic achievement = 4]	-1.114	.675	2.727	1	.099	-2.437	.208
Step	Years of myopia	-.254	.051	24.370	1	.000	-.354	-.153
	[Degree of myopia =1]	-.617	.630	.960	1	.327	-1.853	.618

	Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower	Upper
[Degree of myopia =2]	-.660	.617	1.143	1	.285	-1.870	.550
[Degree of myopia =3]	0[a]	.	.	0	.	.	.

2) Adolescent myopia and mental health

The regression model of degree myopia, years of myopia and mental health was constructed using ordered logistic regression analysis with myopia degree and years of myopia as independent variables and mental health as dependent variable. Among them, the measure of myopia degree involves the sixth and seventh questions of the questionnaire (see Appendix A), the measure of myopia years involves the ninth question, and the measure of mental health involves the twenty-ninth to thirty-fourth questions.

The results of parallel linesa and model fitting information test are shown in the Table 4.20. The results of the parallelism test show that the significance p=0.517>0.05, which indicates that the regression equations are parallel to each other, it is considered that the different categories of dependent variables satisfy the assumption of parallelism and the results of the parameter estimation table are reliable. From the below table, the significance of model fit is 0.025<0.05, which indicates that the model is well fitted and at least one variable in the model is statistically significant.

Table 4.20 Test of parallel linesa and model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	197.750			
General	192.540[b]	5.211[c]	6	.517
Intercept Only	207.141			
Final	197.750	9.391	3	.025

From the Table 4.21, the estimated value of the regression coefficient of myopia years is -0.146, with significance p=0.005<0.05, which is statistically significant, implying that years of myopia has a significant negative effect on mental health; degree 1 of myopia compared to 2 and 3, with significance 0.072, which is statistically significant; the OR value of myopia years is 0.864<1, which means that an increase in myopia years increases the increase the probability of lower mental health; the OR for mild myopia was 0.293<1, indicating that an increase in the degree of myopia increases the probability of lower mental health.

Table 4.21 Estimation of parameters

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Threshold	[Mental health = 1]	-4.662	.776	36.066	1	.000	-6.183	-3.140
	[Mental health = 2]	-3.561	.749	22.609	1	.000	-5.029	-2.093
	[Mental health = 3]	-1.252	.725	2.983	1	.084	-2.673	.169
Step	Years of myopia	-.146	.052	7.812	1	.005	-.248	-.044
	[Degree of myopia =1]	-1.226	.683	3.226	1	.072	-2.564	.112
	[Degree of myopia =2]	-1.076	.669	2.586	1	.108	-2.387	.235
	[Degree of myopia =3]	0[a]	.	.	0	.	.	.

3) Adolescent myopia and quality of life

The regression model of myopia degree, years of myopia and quality of life was constructed using ordered logistic regression analysis with degree of myopia and years of myopia as independent variables and quality of life as dependent variable. Among them, the measure of degree of myopia involves the sixth and seventh questions of the questionnaire (see Appendix A), the measure of myopia years involves the ninth question, and the measure of quality of life involves the twenty-fifth and twenty-sixth questions.

The results of parallel linesa and model fitting information test are shown in the Table 4.22. The results of the parallelism test show that the significance p=0.109>0.05, which indicates that the regression equations are parallel to each other, it is considered that the different categories of dependent variables satisfy the assumption of parallelism and the results of the parameter estimation table are reliable.

From the below table, the significance of model fit is 0.000<0.05, which indicates that the model is well fitted and at least one variable in the model is statistically significant.

Table 4.22 Test of parallel linesa and model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	318.579			
General	296.625[b]	5.211[c]	15	.109

Intercept Only	344.560				
Final	318.579	25.982	3	.000	

As can be seen from the below Table 4.23, the estimated value of the regression coefficient of the years of myopia will be -0.198, with significance p=0.000<0.05, which is statistically significant, implying that the years of myopia will have a significant negative impact on the quality of life; and the estimation of regression coefficients for each group of the degree of myopia is more than 0.05 in terms of significance, which means that the degree of myopia does not have a significant impact on the quality of life.

Table 4.23 Estimation of parameters

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Threshold	[Quality of life = 1]	-3.112	.667	21.767	1	.000	-4.419	-1.805
	[Quality of life = 2]	-2.096	.652	10.336	1	.001	-3.374	-.818
	[Quality of life = 3]	-1.253	.646	3.764	1	.052	-2.518	.013
	[Quality of life = 4]	-.184	.642	.082	1	.775	-1.443	1.075
	[Quality of life = 5]	1.555	.657	5.605	1	.018	.268	2.843
	[Quality of life = 6]	3.957	.853	21.524	1	.000	2.286	5.629
Step	Years of myopia	-.198	.049	16.025	1	.000	-.295	-.101
	[Degree of myopia =1]	-.116	.600	.037	1	.847	-1.293	1.060
	[Degree of myopia =2]	-.354	.590	.361	1	.548	-1.510	.801
	[Degree of myopia =3]	0[a]	.	.	0	.	.	.

4) Adolescent myopia and family medical expenses

The regression models of myopia degree, years of myopia as independent variables and family medical expenses as dependent variables were constructed by using ordered logistic regression analysis to construct regression models of myopia degree, years of myopia and family medical expenses. Among them, the measure of myopia degree involves the sixth and

seventh questions of the questionnaire (see Appendix A), the measure of myopia years involves the ninth question, and the measure of family medical expenses involve the twentieth to twenty-third questions.

The results of the parallelism test show that the significance p=0.998>0.05, which indicates that the regression equations are parallel to each other, it is considered that the different categories of dependent variables satisfy the assumption of parallelism and the results of the parameter estimation table are reliable. The significance of model fit is 0.105 > 0.05, which indicates that the model is poorly fitted.

From the below Table 4.24, the significance of the regression coefficients of regressing the years of myopia and the degree of myopia are greater than 0.05, which indicates that the degree of myopia and the years of myopia do not have a significant effect on the family's medical expenses.

Table 4.24 Estimation of parameters

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Threshold	[Medical expenses = 1]	-.130	.508	.066	1	.797	-1.125	.864
	[Medical expenses = 2]	1.624	.525	9.563	1	.002	.595	2.654
	[Medical expenses = 3]	3.365	.626	28.864	1	.000	2.137	4.592
	[Medical expenses = 4]	3.929	.707	30.909	1	.000	2.544	5.314
	[Medical expenses = 5]	4.625	.866	28.542	1	.000	2.928	6.321
Step	Years of myopia	-.066	.041	2.575	1	.109	-.148	.015
	[Degree of myopia =1]	-.468	.476	.969	1	.325	-1.400	.464
	[Degree of myopia =2]	-.002	.463	.000	1	.997	-.909	.906
	[Degree of myopia =3]	0[a]	.	.	0	.	.	.

5) Adolescent myopia and family lens fitting costs

The regression models of myopia degree, years of myopia and medical expenses were constructed using ordered logistic regression analysis with degree of myopia and years of

myopia as independent variables, and family lens fitting costs as dependent variable. Among them, the measure of myopia degree involves the sixth and seventh questions of the questionnaire (see Appendix A), the measure of myopia years involves the ninth question, and the measure of family lens fitting costs involve the fifteenth, seventeenth and eighteenth questions.

The results of the regression analysis are shown in the Table 4.25. The results of the parallelism test show that the significance p=0.881>0.05, which indicates that the regression equations are parallel to each other, it is considered that the different categories of dependent variables satisfy the assumption of parallelism and the results of the parameter estimation table are reliable.

From the below table, the significance of model fit is 0.027<0.05, which indicates that the model is well fitted and at least one variable in the model is statistically significant.

Table 4.25 Test of parallel linesa and model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	244.671			
General	238.046[b]	6.624[c]	12	.881
Intercept Only	253.872			
Final	244.671	9.202	3	.027

As can be seen from the below Table 4.26, the estimated value of the regression coefficient of the years of myopia is -0.06, with significance p=0.036<0.05, which is statistically significant, implying that the years of myopia has a significant effect on the family lens fitting costs; the degree 2 of myopia is statistically significant at a significance of 0.029 in comparison to 1 and 3, in which the OR for mild myopia is 2.032>1, which indicates that an increase in the degree of myopia will increase the probability of higher cost of prescription glasses.

Table 4.26 Estimation of parameters

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Threshold	[Lens fitting costs = 1]	-.256	.394	.425	1	.515	-1.028	.515
	[Lens fitting costs = 2]	.817	.394	4.302	1	.038	.045	1.589
	[Lens fitting costs = 3]	1.141	.395	8.354	1	.004	.367	1.915

		Estimation	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower	Upper
Step	[Lens fitting costs = 4]	1.453	.396	13.435	1	.000	.676	2.229
	[Lens fitting costs = 5]	1.546	.397	15.172	1	.000	.768	2.324
	Years of myopia	-.060	.029	4.383	1	.036	-.117	-.004
	[Degree of myopia =1]	.709	.370	3.674	1	.055	-.016	1.434
	[Degree of myopia =2]	.798	.365	4.779	1	.029	.083	1.513
	[Degree of myopia =3]	0[a]	.	.	0	.	.	.

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Chapter 5: Results

5.1 Adolescent myopia and hospitals' investment in medical resources

The unit root test shows that the original sequence of the hospitals' investment in medical resources (lnH) and the original sequence of the number of adolescents with myopia (lnQ) were both stationary sequences. Through the Engle-Granger two-step test, it was found that there existed a cointegration relationship between the number of adolescents with myopia (lnQ) and hospitals' investment in medical resources (lnH), which indicated that the linear combination of these two non-stationary time series could mutually offset the impact of trend items, thus forming a stable time series.

The cointegration regression equation estimated by the least square method (OLS) reveals the relationship between hospitals' investment in medical resources and the number of adolescents with myopia, and the equation was statistically significant with high goodness of fit. Furthermore, the stationarity of the residual sequence was analyzed with the unit root test (ADF test), and the results showed that the residual sequence was significant at the significance level of 5%, indicating that it was stationary, there existed a long-term stable dynamic equilibrium relationship between hospitals' investment in medical resources and the number of adolescents with myopia.

To sum up, there existed a stable correlation between hospitals' investment in medical resources and the long-term trend of the number of adolescents with myopia. However, this conclusion only shows the long-term equilibrium relationship between the two variables, and it does not directly prove that the change in the number of myopia patients is the reason for the investment of medical resources. To determine the causal relationship, the Granger causality test was conducted for further study and analysis, and the results showed that the change of the number of adolescents with myopia was the Granger cause of the change of hospitals' investment in medical resources, when the lag period is one year.

5.2 Adolescent myopia and investment in myopia prevention and control materials in primary and secondary schools

The results of unit root test showed that the original sequence of the number of adolescents with myopia (lnQ) was stationary, while the investment in myopia prevention and control materials in primary and secondary schools (lnS) was non-stationary. After the difference treatment, the second-order difference sequence ($\Delta^2 lnS$) of the input cost of myopia prevention and control materials in primary and secondary schools was significant at 1% confidence level, which was a stationary sequence. Based on the data of the number of adolescents with myopia (lnS) and the investment in myopia prevention and control materials in primary and secondary schools (lnQ) in Dalian, the long-term and short-term relationship between them was studied with the cointegration analysis and error correction model. The Engle-Granger two-step test was performed, and the results showed that there existed a long-term and stable dynamic equilibrium relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools. This indicates that the long-term changes of the two were interrelated and balanced. The statistics of the coefficients of cointegration regression equation were significant at the set confidence level, with high degree of goodness of fit of the model, which further supports the conclusion that there exists a long-term equilibrium relationship between them. On the basis of the cointegration analysis, an error correction model was built to study the short-term dynamics and long-term adjustment characteristics of the model. The results show that the short-term changes in the investment in myopia prevention and control materials in primary and secondary schools were affected by the disequilibrium degree in the previous period, there existed a short-term correction effect. When the short-term fluctuation deviates from the long-term equilibrium, the system would pull the unbalanced state back to the equilibrium state with certain adjustment.

The results of the Granger causality test show that there existed a significant causal relationship between them. Under the analysis framework of set time series, the lag period of 1 to 3 years was tested year by year. The test results showed that the null hypothesis that "lnQ is not the Granger cause of lnS" was rejected when the lag period was one year, indicating that the change in the number of adolescents with myopia could significantly reflect and predict the change in investment in myopia prevention and control materials in primary and secondary schools in the future, at the significance level of 5%. This finding not only verifies the long-term stable dynamic equilibrium relationship revealed by cointegration analysis, but also

further clarifies the causal impact of the number of adolescents with myopia on the investment in myopia prevention and control materials in primary and secondary schools. Specifically, the increase of the number of adolescents with myopia would significantly drive the increase of investment in myopia prevention and control materials in primary and secondary schools. This conclusion provides an important reference for policy makers when designing and implementing myopia prevention and control strategies, to fully consider the changing trend of the number of adolescents with myopia, and rationally plan and allocate myopia prevention and control resources accordingly, so as to ensure the effective utilization of resources and implementation of prevention and control strategies.

5.3 Adolescent myopia and government's health policies and vision health investment

The unit root test shows that the original series of the number of adolescents with myopia *(lnQ)* and the government's health policies and vision health investment *(lnG)* were stationary, which provides the necessary conditions for the subsequent cointegration analysis. The Engle-Granger two-step test was further performed, and the results show that there existed a long-term and stable dynamic equilibrium relationship between the number of adolescents with myopia and the government's health policies and vision health investment. The results of the cointegration regression equation show that the government health policy and vision health investment are not only related to the time trend, but also related to the number of myopia among adolescents. This finding provides an important insight for policy makers, i.e. the issue of adolescent myopia may have a long-term impact on government's health policies and vision health investment.

To further explore the dynamic characteristics of the long-term equilibrium relationship, an error correction model was studied and constructed. The model shows that the short-term changes in the government's health policies and vision health investment were affected by the disequilibrium degree in the previous period, i.e. there exists a short-term correction effect. When the short-term fluctuation deviates from the long-term equilibrium, the system would make adjustment through its inherent balancing mechanism, to pull the disequilibrium state back to the equilibrium state with certain intensity, which provides the basis for further exploring the causal relationship between them.

The results of the Granger causality test showed that when the lag period was one year, for

the null hypothesis "lnQ is not the Granger cause of lnG", F value was 7.037, and P value was 0.026, which were significant at the significance level of 5%. Therefore, the original hypothesis was rejected, indicating that the early changes in the number of adolescents with myopia could significantly affect the future changes in government's health policies and vision health investment. When the lag period is 2 years, F value further increased to 26.147, and P value was 0.001, significant at the significance level of 1%, which further supports the conclusion that the number of adolescents with myopia is the Granger cause of the government's health policies and vision health investment. However, when the lag period is 3 years, F value decreased to 1.645, and P value was 0.346, indicating that during this lag period, the impact of the number of adolescents with myopia on the future government's health policies and vision health investment was no longer significant.

5.4 Adolescent myopia and social organizations' investment in publicity and education on myopia prevention and control

Through ADF unit root test, cointegration analysis and error correction model, the in-depth investigation was made on the dynamic relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control. First of all, the ADF unit root test shows that the original sequence (lnQ) of the number of adolescents with myopia and the original sequence (lnC) of the social organizations' investment in publicity and education on myopia prevention and control were stationary sequences, which meet the preconditions of the subsequent Granger causality test. Secondly, the results of the Engle-Granger two-step cointegration test show that there existed a long-term and stable dynamic equilibrium relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control. The social organizations' investment in publicity and education on myopia prevention and control was not only related to the year of investment, but also significantly affected by the number of adolescents with myopia. Furthermore, the results of residual unit root test show that the residual sequence E was significant at 1% confidence level, a stationary sequence, thus confirming the cointegration relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control.

On the basis of revealing the long-term equilibrium relationship, the short-term dynamic

and long-term adjustment characteristics between variables were studied by using the error correction model (ECM). The results of the error correction model show that the short-term changes in social organizations' investment in publicity and education on myopia prevention and control were affected by the unbalanced degree in the previous period, i.e. when the short-term fluctuations deviated from the long-term equilibrium, the system would pull the disequilibrium state back to the equilibrium state with certain adjustment efforts. To further clarify the causal relationship between them, the Granger causality test was conducted for these two variables. Within the set lag period (1 to 3 years), the test results rejected the possibility that the number of adolescents with myopia was the Granger cause of the change in social organizations' investment in publicity and education on myopia prevention and control. Specifically, when the lag period was 1 year, 2 years and 3 years respectively, the values of F statistics were not significant (they were not significant at 10% confidence level), so the null hypothesis that "lnQ is not the Granger cause of lnC" was accepted. This shows that in the current data sample and the selected lag period, the change of the number of adolescents with myopia had not significantly caused the adjustment of social organizations' investment in publicity and education on myopia prevention and control. However, due to the limitation of data acquisition, the time series data of the study only covers the data in 13 years from 2010 to 2022, and considering that the response of adolescent myopia to publicity and education investment of social organizations may have a long lag period, there may exist the Granger causality relationship between the two variables in a longer lag period.

5.5 Adolescent myopia and family medical expenses and lens fitting costs

The effects of gender, age and educational background on family medical expenses and lens fitting costs were studied by Chi-square test. The results showed that there were no significant differences in family medical expenses and lens fitting costs among different genders (p>0.05). The effect of age on medical expenses was not significant (p=0.233), which may be due to the fact that medical expenses are not directly affected by age, but by other factors such as family economic conditions and medical insurance coverage. Age had a significant effect on the lens fitting costs (p=0.005). There are differences in lens fitting costs among students of different ages, which may be related to factors such as age-related vision changes and the choice of glasses styles. There was no significant difference in family medical expenses among myopic adolescents with different educational background (p>0.05), and there was a significant difference in lens fitting costs (p<0.05), which may be due to the fact that children's functional

needs for glasses may increase with the improvement of school years. For example, children in junior high school may be more inclined to choose lenses with anti-blue light, anti-fatigue and other functions, and the price of these lenses is usually higher.

The rank sum test of multiple independent samples was used to further explore the differences among variable groups. In the paired comparison of lens fitting costs, this study found that there was no significant difference between the 16-18 age group and the 13-15 age group in lens fitting costs (p=1.000); There was a statistically significant difference in lens fitting costs between 16-18 years old and 6-12 years old (p=0.008). There was also a significant difference in lens fitting costs between 13-15 years old and 6-12 years old (p=0.015). The pin-to-pair comparison of educational background on the difference of lens fitting costs showed that no significant difference was found between the high school education group and the middle school education group (p=0.337). However, there was a statistically significant difference between high school education and primary school education (p=0.001). In addition, there was a significant difference in lens fitting costs between junior high school education and primary school education (p=0.034).

In the regression analysis of adolescent myopia and family medical expenses, the significance of the regression coefficient between myopia years and medical expenses was p=0.109>0.05, indicating that myopia years did not have a significant impact on family medical expenses. The significance of the regression coefficients between the degree of myopia (mild myopia, moderate myopia) and medical expenses were 0.325 and 0.997, respectively, both greater than 0.05. Therefore, the degree of myopia did not have a significant impact on medical expenses.

Regression analysis of myopia and lens fitting costs in adolescents shows that the degree of myopia has a significant impact on lens fitting costs. The significance of moderate myopia compared with mild myopia and severe myopia is p=0.029, and the OR value of mild myopia is 2.032>1, indicating that the increase of myopia degree will increase the probability of lens fitting costs. The regression coefficient between the years of myopia and lens fitting costs is -0.06 (p=0.036), which means that the years of myopia have a significant impact on lens fitting costs.

5.6 Adolescent myopia and individual mental health, academic achievement, quality of life

Since mental health, quality of life, and academic achievement are classified by quantitative

variables, this study explores the effects of gender, age, and educational background on mental health, quality of life, and academic achievement through Chi-square test. The results showed that gender did not show significant differences in all these variables (p>0.05). This shows that the samples of different genders show consistency in mental health, quality of life and academic achievement, and there is no obvious gender difference. Age had no significant effect on mental health (p=0.251), but had significant effect on quality of life and academic level (p=0.000). Individuals of different ages show significant differences in quality of life and academic achievement, which reflects the stage and complexity of adolescent psychological development, as well as the different situations that different ages may face. With the growth of students, their knowledge accumulation, learning methods, learning ability and other aspects may lead to differences in academic achievement. There were no significant differences in mental health among myopic adolescents with different educational background (p>0.05), but significant differences in quality of life and academic achievement (p<0.05).

Based on the results of Chi square test, the rank sum test of multiple independent samples was used to further explore the differences among variable groups. The results showed that there was a statistically significant difference between the 16-18 age group and the 13-15 age group (p=0.000). Similarly, there was a statistically significant difference in academic achievement between the 16-18 age group and the 6-12 age group (p=0.000); In addition, the academic achievement of the 13-15 age group was significantly different from that of the 6-12 age group (p=0.001); The pairwise comparison of quality of life in different age groups showed that there was a statistically significant difference in quality of life between 16-18 years old and 13-15 years old (p=0.005). There was a significant difference in quality of life between the 16-18 age group and the 6-12 age group (p=0.000). In addition, the difference in quality of life between the 13-15 age group and the 6-12 age group was equally significant (p=0.000); In the paired comparison of educational background in academic achievement, the following significant differences were found: There was a statistically significant difference between high school education and middle school education in academic achievement (p=0.000); There was also a significant difference between high school education and primary school education (p=0.000). There was also a significant difference between junior high school education and primary school education (p=0.000). The pair-to-pair comparison of quality of life based on educational background shows that there is no significant difference between high school education and middle school education; However, there was a significant difference in quality of life between high school education and primary school education (p=0.000). Similarly, there was a significant difference in quality of life between those with a junior high school education

and those with a primary school education (p=0.000).

In the regression analysis of adolescent myopia and individual academic achievement, the estimated regression coefficient of myopia years and academic achievement is -0.254 (p=0.000), indicating that myopia years have a significant negative impact on academic achievement. The estimated regression coefficients of each group with myopia degree were not statistically significant (p>0.05), indicating that the degree of myopia had no significant effect on academic achievement, which may be because the degree of myopia does not directly determine the learning ability and academic performance of adolescents. Academic achievement is affected by many factors, including personal learning habits, intelligence level, educational resources, etc. These factors may have a more significant impact on academic achievement than the degree of myopia.

In the regression analysis of myopia and individual mental health in adolescents, the estimated value of the regression coefficient of myopia years was -0.146, and the significance p=0.005, which was statistically significant, indicating that myopia years had a significant negative impact on mental health. With the increase of years of myopia, adolescents' mental health may be more negatively affected, long-term myopia may lead to adolescents in social, learning and life to face more difficulties and challenges, and thus have a negative impact on their mental health; The regression results of myopia degree and mental health showed that the significance of mild myopia compared with moderate myopia and severe myopia was p=0.072<0.1, which had statistical significance. The OR value of the years of myopia was 0.864<1, indicating that the increase of the years of myopia would increase the probability of the decrease of mental health level. The OR value of mild myopia was 0.293<1, indicating that the increase of myopia degree would increase the probability of decreasing mental health level. Moderate myopia had no significant effect on adolescents' mental health. This may be because the degree of myopia is a relatively objective indicator, and mental health is affected by a variety of subjective and objective factors, the degree of myopia is not the main influencing factor; In the future, while paying attention to the problem of myopia in adolescents, it is also necessary to pay attention to its impact on mental health, further research and explore the reasons and mechanisms behind it, in order to develop more effective intervention strategies.

In the regression analysis of myopia and quality of life in adolescents, the regression coefficient between myopia years and quality of life was -0.198 (p<0.05), indicating that myopia years have a significant negative impact on quality of life in adolescents. The longer the years of myopia, the lower the quality of life of adolescents may be, which may be because teenagers with longer years of myopia face more inconvenience and challenges in daily life and

learning, which affects their daily life; The estimated significance of regression coefficients in each group of myopia degree was greater than 0.05, indicating that myopia degree had no significant effect on quality of life.

5.7 Summary of results

As the adverse effects of myopia on the vision health of adolescents continue to gain prominence, this study, grounded in stakeholder theory, employs adolescents in Dalian City as the survey subject to examine the socioeconomic impact of adolescent myopia across multiple levels, including hospitals, schools, government agencies, social organizations, families, and individual participants.

A data analysis based on the stakeholder perspective revealed a significant contribution of the number of adolescents with myopia to the hospitals' investment in medical resources. Furthermore, the analysis indicated that an increase in the number of myopes will lead to an increase in the investment in medical resources in the future. The analysis conducted in this study employed cointegration analysis and an error correction model, which demonstrated the existence of a long-term, stable dynamic equilibrium relationship between hospitals' investment in medical resources and the number of adolescents with myopia. On this basis, the study, employing the Granger causality test for time series data, demonstrated that there is a Granger causality relationship between the number of adolescents with myopia and hospitals' investment in medical resources. A one-year lag period is significant at the 5% confidence level. This implies that changes in the number of adolescents with myopia in the previous period can explain future hospitals' investment in medical resources. Consequently, the number of adolescents with myopia is the Granger cause of the hospitals' investment in medical resources.

A data analysis based on the stakeholder perspective of schools revealed a significant contribution of the number of adolescents with myopia to the investment in myopia prevention and control materials in primary and secondary schools. Furthermore, the analysis indicated that an increase in the number of myopes will lead to an increase in schools' investment in myopia prevention and control materials in the future. The analysis conducted in this study employed cointegration analysis and an error correction model, which demonstrated the existence of a long-term, stable dynamic equilibrium relationship between investment in myopia prevention and control materials in primary and secondary schools and the number of adolescents with myopia. On this basis, the study, employing the Granger causality test for time series data, demonstrated that there is a Granger causality relationship between the number of

adolescents with myopia and investment in myopia prevention and control materials in primary and secondary schools. A one-year lag period is significant at the 5% confidence level. This implies that changes in the number of adolescents with myopia in the previous period can explain future investment in myopia prevention and control materials in primary and secondary schools.

A data analysis based on the stakeholder perspective of the government revealed a significant contribution of the number of adolescents with myopia to the government's health policies and vision health investment. Furthermore, the analysis indicated that an increase in the number of myopes will lead to an increase in the government's health policies and vision health investment in the future. The analysis conducted in this study employed cointegration analysis and an error correction model, which demonstrated the existence of a long-term, stable dynamic equilibrium relationship between the government's health policies and vision health investment and the number of adolescents with myopia. The results of the Granger causality test show that there is a Granger causality between the number of adolescents with myopia and the government's health policies and vision health investment. The lag period of 1-2 years is significant at a 5% and 1% confidence level, respectively. This implies that changes in the number of adolescents with myopia in the previous period can explain the future changes in the government's health policies and vision health investment. Consequently, the number of adolescents with myopia is the Granger cause of the government's health policies and vision health investment.

A data analysis based on the stakeholder perspective of social organizations indicates that there is no Granger causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control when the lag period is 1 to 3 years. When the lag period is 1-3 years, the result is not significant at the significance level of 10%. However, it is also possible to be significant within a longer lag period due to the limited availability of relevant data before 2010, so only time sequence data in 13 years from 2010 to 2022 were extracted, with a lag period of only three years. The response time of myopia in adolescents to the investment in publicity and education on myopia prevention and control by social organizations is longer compared to hospital and school entities that are closely related to myopia. The lag period may be even longer, and it is anticipated that there will be a Granger causality between the two over a longer lag period.

The data analysis based on the perspective of family as a stakeholder shows that the age and degree of myopia have a significant impact on lens fitting costs. Among them, the significance of moderate myopia is p=0.029 compared with mild myopia and severe myopia,

and the OR value of mild myopia is 2.032>1, indicating that the increase of myopia degree will increase the probability of increasing lens fitting costs. The estimated significance of the regression coefficient of myopia age and myopia degree on family medical cost is greater than 0.05, indicating that myopia age has no significant effect on family medical cost.

Based on the data analysis from the perspective of individual as a stakeholder, the estimated regression coefficient between years of myopia and academic level was -0.254 (p=0.000), indicating that years of myopia had a significant negative impact on academic achievement. The estimated regression coefficients of each group with myopia degree were not statistically significant (p>0.05), suggesting that myopia degree had no significant effect on academic achievement. The estimated value of myopic years on mental health regression coefficient was -0.146, and the significance p=0.005, indicating that myopic years had a significant negative effect on mental health. The regression results of myopia degree and mental health showed that myopia degree had a significant negative impact on mental health (p=0.072<0.1), and the OR value of mild myopia was 0.293<1, indicating that the increase of myopia degree would increase the probability of decreasing mental health level. The regression coefficient between the years of myopia and the quality of life was -0.198 (p<0.05), indicating that the years of myopia had a significant negative effect on the quality of life of adolescents. The estimated significance of regression coefficients in each group of myopia degree was greater than 0.05, indicating that myopia degree had no significant effect on quality of life.

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Chapter 6: Discussion

6.1 Adolescent myopia and hospitals' investment in medical resources

For the hospital as a stakeholder, it was found in this study through data analysis and the Granger causality test, that the increase of the number of adolescents with myopia played a significant role in promoting the hospitals' investment in medical resources. This finding provides a new perspective for us to understand the socioeconomic impact of adolescent myopia. First of all, there was a direct correlation between the growth in the number of adolescents with myopia and the increase of hospitals' investment in medical resources. From the perspective of the hospital, this includes increasing the number of ophthalmologists, nurses and other medical staff, purchasing and maintaining more medical equipment, and providing more medical services and treatment options. Furthermore, the results of the Granger causality test provide strong support for our conclusion. The test on time series data shows that there existed the Granger causality between the number of adolescents with myopia and the hospitals' investment in medical resources. This indicates that, the change of the number of adolescents with myopia is, statistically, the reason for the change of hospitals' investment in ophthalmic medical resources. Specifically, for the lag period of one year and at the significance level of 5%, the early changes in the number of adolescents with myopia could significantly reflect the hospitals' investment in medical resources in the future.

When the lag period is one year, the hospital may adjust the resource input one year after the data of juvenile myopia changes. The delay of this coping mechanism leads to the untimely allocation of resources, which may affect the prevention and control effect. In order to cope with the impact of the lag period, first of all, a real-time data monitoring system should be established. Hospitals should establish a long-term cooperation mechanism with education departments and community health service institutions, and realize the dynamic collection and real-time update of myopia prevalence data through regular vision screening and the establishment of electronic health records. It is suggested to adopt information means, such as developing data sharing platform, to ensure the timeliness and accuracy of data, so as to identify the changing trend of myopia number earlier and provide scientific basis for resource adjustment. Secondly, it is necessary to establish a scientific prediction model, and use time

series analysis, machine learning and other tools to combine historical data and real-time data to establish a prediction model of myopia incidence to predict the growth of myopia in the next one to two years, so as to plan resources in advance. In terms of dynamic resource allocation mechanism, it is necessary to formulate flexible human resource allocation strategies, such as training multi-skilled medical staff, establishing a temporary employment mechanism, and rapidly increasing manpower at peak demand. In terms of equipment, we can consider renting or sharing equipment to avoid long-term idleness, and at the same time establish a rapid procurement channel with suppliers to ensure that urgently needed equipment can be in place in time. Through the implementation of the above systematic measures, we can realize the paradigm shift from passive response to active prediction, from rigid supply to elastic adaptation, build a scientific and efficient prevention and control system for juvenile myopia, and better cope with the challenge of continuous medical resources. At the same time, it is suggested to establish an effect evaluation mechanism, regularly evaluate the implementation effect of measures, and continuously optimize prevention and control strategies to ensure the accuracy and effectiveness of resource investment.

However, we also need to be aware of the complexity behind this conclusion. The increase in the number of adolescents with myopia may be the result of many factors, including the change of lifestyle, increase of study pressure and the popularization of electronic products. Therefore, in-depth studies shall be conducted to explore the interaction and influence between these factors in the future. In addition, we also need to pay attention to other socioeconomic impacts caused by the issue of adolescent myopia, for example, myopia may affect the study and employment opportunities, thus having a potential impact on the economic development of the whole society. At the same time, with the increase of medical resources, the operating cost of hospitals may also rise, which may put some pressure on the medical insurance system. Therefore, we need to consider how to effectively cope with the challenges brought by adolescent myopia from a broader perspective.

Comparing the results of this study with those of previous studies, it is found that the existing studies also suggested that with the increase in the number of adolescents with myopia, the demand for ophthalmic services is also increasing. For social and economic impact, both the previous studies and this study emphasized the socioeconomic impact of adolescent myopia. For example, the increase in medical resources may mean an increase in the economic burden of the society on myopia treatment. However, more robust and quantitative evidence for the correlation was provided through the Granger causality test in the study. This difference in methodology makes the conclusion of this study more convincing. The time lag between the

number of adolescents with myopia and the investment in medical resources of hospitals was highlighted in the study, the change of the number of adolescents with myopia can significantly affect the hospitals' investment in medical resources after one year. This finding provides a more specific reference for policy makers, helping them better predict and plan the future investment in medical resources.

As an important stakeholder related to myopia, medical institutions can play an important role in alleviating the current condition of adolescent myopia. Medical institutions should actively carry out health education activities on prevention and control of myopia, entering schools, communities and families to popularize the knowledge of the harm, causes and prevention and control of myopia to parents, children and adolescents; arrange education activities, to help adolescents to establish a scientific concept of using their eyes and improve their awareness of eye care and protection; provide personalized prevention and control programs for adolescents with myopia, and personalized prevention and control services, and develop personalized prevention and control programs for different ages and degrees of myopia, to offer more accurate and effective prevention and control measures for adolescents; enhance cooperation with scientific research institutions and universities, to jointly carry out scientific research on myopia prevention and control; and through cooperation in scientific research, promote the innovation and development of myopia prevention and control technology, to provide more effective prevention and control means for adolescents.

6.2 Adolescent myopia and investment in myopia prevention and control materials in primary and secondary schools

Through in-depth analysis of the data and Granger causality test, this study concluded that the increase in the number of teenagers with myopia has a significant positive impact on the increase in the input of myopia prevention and control materials in primary and secondary schools, that is, with the increase in the number of myopic students, schools need to invest more resources to strengthen the prevention and control of myopia. Such resources include, but are not limited to, vision testing equipment, educational materials for myopia prevention and control, and facilities for improving the learning environment. Increase in such investment not only helps to improve students' vision health, but also helps reduce other potential health risks caused by myopia. The results of the Granger causality test further demonstrated such causal relationship between them. When the lag period is one year, the early changes in the number of adolescents with myopia could significantly reflect the future change in the investment in

myopia prevention and control materials in primary and secondary schools.

In view of the lag of juvenile myopia prevention and control materials, schools should establish a systematic and dynamic prevention and control system, effectively resolve the impact of the lag through scientific prediction and early layout, and realize the transformation from passive response to active prevention and control. First of all, we should establish a dynamic monitoring platform for myopia rate in schools, implement a semester vision survey system, and build electronic health records for students. By tracking the changes of students' vision for a long time, we can find potential problems in time and avoid the lag of prevention and control measures caused by data faults. At the same time, it is necessary to establish a short-sighted material demand reserve mechanism, the basic inventory should meet the annual regular demand, and the emergency reserve should be configured to cope with the sudden increase in demand, so as to alleviate the lag problem caused by the long procurement cycle of materials. In addition, it is necessary to strengthen the multi-dimensional coordination mechanism, build a linkage system between schools and doctors, and build a prevention and control demonstration base with eye hospitals to carry out quarterly joint screening and effect evaluation. Differentiated resource allocation should be implemented for school scenes, and the allocation should be optimized according to the scenes. For example, intelligent light environment system and multimedia blue-light prevention equipment should be adopted in classrooms, outdoor vision recovery areas and green plant observation areas should be set up in students' frequent activities areas, and professional equipment should be configured for different scenes to provide immediate intervention measures to avoid worsening vision problems due to lagging intervention.

Most of the existing studies emphasized the impact of adolescent myopia on myopia prevention and control of the schools, As far as you know, provided in-depth discussion on the causality and dynamics of such impact (H. B. Zhang et al., 2024; R. X. Tian, 2024; Y. W. Zheng & Xu, 2024). Through the Granger causality test, this study not only revealed the causal relationship between the number of adolescents with myopia and the investment in myopia prevention and control materials in primary and secondary schools, but also quantified the time lag of this relationship. This finding can facilitate us to have more in-depth and comprehensive understanding of the relationship between the two factors, and also provides a new direction for the subsequent studies.

The school is an important place for study and growth of children and adolescents, so a series of comprehensive measures should be taken in the school to alleviate the current situation of myopia in adolescents. The schools should strengthen health education for students,

incorporate myopia prevention and control knowledge into the curriculum system, and arrange relevant lectures and publicity activities on a regular basis, so that students can understand the harm, causes and scientific prevention and control methods of myopia; properly maintain the environment management under the guidance of the government, to improve the learning environment for students, ensure that natural lighting, lamps, desks and chairs, blackboards and other teaching tools in the classroom meet the requirements, and adjust the heights of desks and chairs individually according to the growth and development of students; conduct effective health education and learning management, arrange courses reasonably, and improve the physical education curriculum, to avoid long-term continuous study of students, ensure students have enough time for rest and relaxation, prevent myopia, and promote the all-round development of students in morality, intelligence, physique, beauty and labor. The schools shall strengthen campus publicity and education, and include the knowledge on myopia prevention and control into classroom teaching and the code of conduct for students. The schools may also establish partnership with medical institutions, inviting ophthalmologists to carry out vision screening and free clinic activities on campus, to identify and intervene vision problems of students timely; establish the student vision files, regularly track their vision status, and provide personalized recommendations on prevention and control to students with myopia.

6.3 Adolescent myopia and government's health policies and vision health investment

In respect of the socioeconomic impact of adolescent myopia in China, the government is a key stakeholder, and its health policies and vision health investment are of great significance for controlling myopia. According to the results of the study, the increase in the number of adolescents with myopia would significantly boost the government's health policies and vision health investment. This finding not only reveals the seriousness of adolescent myopia, but also highlights the role and responsibility of the government in coping with this problem. There existed a long-term and stable dynamic equilibrium relationship between the increase in the number of adolescents with myopia and the government's health policies and vision health investment. This relationship shows that with the increase in the number of adolescents with myopia, the government would adjust its health policies and increase investment in vision health accordingly to cope with this public health problem. Such adjustment is necessary and timely, because adolescent myopia not only affects the physical and mental health of students, but also may have a negative impact on the future labor force of the country. The results of the

Granger causality test show that when the lag period is 1-2 years, the early changes in the number of adolescents with myopia could significantly reflect the future changes in the government's health policies and vision health investment. This shows that the increase in the number of adolescents with myopia was an important driving force for the government to adjust its health policies and increase its investment in vision health.

In view of the lag relationship between the change of juvenile myopia and the government's health policy and visual health investment, the government should take systematic measures to alleviate the impact of the lag and achieve a more efficient policy response. First of all, we should establish a forward-looking policy-making mechanism, build a national big data platform for teenagers' vision health, collect students' vision data in real time, set a policy trigger threshold, predict the change trend of myopia rate 1-2 years in advance through data prediction, and make a three-year myopia prevention and control plan, which will be dynamically adjusted according to the latest data every year, and at the same time, establish a policy reserve (such as grading response plan), quickly start corresponding measures according to the change of myopia rate, and also formulate differentiated regional prevention and control policies based on the prediction results to avoid "one size fits all" In addition, a special fund for myopia prevention and control will be set up to ensure the stability and continuity of prevention and control investment and avoid the lag of funds caused by the budget cycle.

Most of the studies mentioned above discussed the relationship between adolescent myopia and government's health policies and vision health investment (J. Ma, 2022; Zeng, 2018), but this study was conducted with more in-depth and comprehensive analysis methods, such as cointegration analysis, error correction model and Granger causality test, to enable us to reveal the long-term stable dynamic equilibrium relationship and causal relationship between them more accurately. The results of the Granger causality test show that the early changes in the number of adolescents with myopia could reflect the changes in government's health policies and vision health investment in the next 1-2 years. This reveals the lag period between the number of people with myopia and government policies and investment, which was not fully discussed or verified in existing studies.

Prevention and control of myopia requires the cooperation of many stakeholders, and the government should play the leading role and actively undertake the comprehensive management, financial support, equipment supply, supervision and management. The government can establish the special fund for prevention and control of myopia to support schools, medical institutions and communities for myopia prevention and control. The

government should increase the investment in medical insurance funds, to ensure adolescents can get professional diagnosis, treatment and rehabilitation services timely when they encounter vision problems, and also promote the reform of the medical insurance system, and include myopia correction surgery into the scope of medical insurance, to reduce the economic burden of families. Funds shall also be injected to support scientific research and innovation related to myopia prevention and control, and encourage scientific research institutions and universities to develop and popularize new technologies and methods for myopia prevention and control. The efficiency and effect of myopia prevention and control shall be improved through scientific and technical innovations, to provide better prevention and control services for adolescents. In brief, the government should provide all-round financial support according to the actual needs of myopia prevention and control, to ensure the comprehensive promotion and effective implementation of myopia prevention and control, and strengthen the supervision and evaluation, to ensure the transparency and efficiency of the use of funds.

6.4 Adolescent myopia and social organizations' investment in publicity and education on myopia prevention and control

The study focuses on the socioeconomic impact of social organizations as stakeholders on the issue of adolescent myopia in China. It was found in the analysis that the increase of the number of adolescents with myopia had a significant role in promoting the investment of social organizations in publicity and education of myopia prevention and control. The increase of the number of adolescents with myopia triggered the increase of social organizations' investment in publicity and education on myopia prevention and control, which shows that social organizations paid due attention to the issue of adolescent myopia and are willing to promote myopia prevention and control through publicity and education. Such kind of investment from social organizations can not only improve the understanding of myopia of the public, but also help adolescents develop the good eye using habits, thus reducing the occurrence of myopia. However, it is worth noting that although there existed a positive correlation between the increase in the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control, there was no significant Granger causality between them with the lag period of 1-3 years in the Granger causality test. This may be related to the response mechanism of social organizations in publicity and education of myopia prevention and control. Compared with hospitals, schools and other institutions in close contact with adolescent myopia, social organizations may need longer time to plan, organize

and implement related publicity and education activities after receiving the signal that the number of adolescents with myopia is increasing. Therefore, the causal relationship between the two may not be significant in a short lag period. Considering the characteristics of social organizations in respect of publicity and education of myopia prevention and control, we speculate that in a longer lag period, there may be a significant Granger causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control. With the lapse of time, social organizations will have more opportunities and resources to respond to the challenges of adolescent myopia and increase their investment in the publicity and education of myopia prevention and control.

Comparing the results of this study on the socioeconomic impact of social organizations on adolescent myopia in China with previous studies, we can see that both this study and previous studies recognize the important role of social organizations in the prevention and control of myopia. There exists a certain relationship between the increase in the number of adolescents with myopia and the investment of social organizations in myopia prevention and control publicity and education, indicating the social organizations' attention and investment in myopia prevention and control increasing with the increasingly serious myopia problem. For the differences from previous studies, the present study was conducted from the perspective of stakeholders, for in-depth discussion on the socioeconomic impact of social organizations on adolescent myopia, and analysis on the dynamic relationship between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control. Previous studies paid more attention to the medical, educational or social aspects of myopia, without in-depth analysis from the perspective of stakeholders.

Social organizations should shoulder social responsibilities, e.g. disseminating scientific health knowledge on myopia prevention and control through online media, TV newspapers, animated advertisements and other channels; arranging large-scale education activities on myopia prevention and control, and popularizing the harm, causes and prevention methods of myopia to adolescents and their parents through various media channels (such as social media, school lectures, home visits). In terms of funds, social organizations can also support and fund scientific research related to myopia prevention and control, including epidemiological investigation and effect evaluation of intervention measures, provide data support for formulating scientific prevention and control strategies, support universities and scientific research institutions to establish optometry majors, train more professionals, provide manpower support for myopia prevention and control, strengthen exchanges and cooperation with international organizations and other countries, and learn from advanced myopia prevention

and control concepts and technologies. They may participate in international myopia prevention and control research projects to jointly promote the development of prevention and control of adolescent myopia around the world. Through the above measures, social organizations can play an active role in alleviating the current situation of myopia in adolescents and protect their vision health.

6.5 Adolescent myopia and family medical expenses and lens fitting cost

In the family as a stakeholder part, the study found that the degree of myopia has a significant positive impact on lens fitting cost, revealing the direct economic consequences of myopia on families. Increasing myopia is often accompanied by an increase in eye health problems, such as visual fatigue, dry eye, retinopathy. These eye health problems often require professional medical intervention and treatment, which includes not only the cost of lenses and frames, but also the cost of optometry, optometry and other services. That is, an increase in the degree of myopia may lead to a need for more complex and expensive glasses or lenses, and therefore a higher expenditure on the cost of optometry for families. The impact of myopia on family economic burden actually reflects deeper social and economic problems. Differences in family economic conditions may lead to unequal access to resources for myopia prevention and treatment among adolescents. Families with better economic conditions may have better access to high-quality eye health services and products, while families with less economic conditions may face more financial stress.

The empirical analysis results show that the OR value of mild myopia is 2.032, indicating that the higher the degree of myopia, the greater the probability of increasing the cost of glasses. In view of the cost of glasses, it is suggested that the government establish a graded glasses subsidy mechanism to provide different subsidy ratios for mild myopia, moderate myopia and severe myopia, so as to reduce the financial burden of families. It is also possible to set up "public welfare glasses points" in schools and communities to provide basic lenses, so as to reduce the cost of glasses for families and reduce the delay of glasses due to economic pressure. Social organizations can set up public welfare funds to improve the attention and participation of society in myopia prevention and control, provide glasses subsidies and medical expenses assistance for low-income families, and ensure that all children can get the necessary vision correction services. Through the above measures, the government and social organizations can alleviate the impact of myopia on family economic burden, promote the implementation of myopia prevention and control measures, and provide all-round protection for teenagers' vision

health.

Increased myopia among adolescents leads to a general increase in family spending on the optician costs, a conclusion that has been confirmed in the previous studies and in this study. However, there are some differences between this study and existing studies in the study perspective. This study focuses on the family, one of the important stakeholders, from the perspective of stakeholders, while previous studies mostly discussed myopia from the perspectives of medicine, public health or education. Future studies may further explore the economic influencing factors of the family and mechanisms of myopia, study the differences and characteristics of adolescent myopia under different socioeconomic backgrounds, to provide scientific basis for developing more effective prevention and control strategies for myopia.

The family and parents are the first responsible persons for children's health and myopia protection, playing a vital role in preventing and controlling adolescent myopia. Parents should encourage their children to participate in outdoor activities, such as walking, running and ball games. Natural light has nutritional and protective functions for eyeball development, to relieve eye fatigue and prevent myopia. It is necessary to arrange at least one hour of outdoor activities for children every day, and try to let them play and study outdoors; Parents shall ask their children to maintain the correct sitting posture during their study, and keep the appropriate distance between the eyes and the book or the screen, so as to avoid bending the head or twisting the neck for a long time; remind them to rest the eyes regularly, and follow the "20-20-20" rule: look at objects 20 feet (about 6 meters) away after reading/writing for 20 minutes, and rest for at least 20 seconds; provide sufficient lighting for the children, and avoid studying under insufficient light or strong light. Parents shall also control children's use of electronic products in daily life, in particular, when they use electronic products at night and in a dark environment, ensure that the screen brightness is moderate and the font size is appropriate, to avoid eye fatigue. Parents shall take their children to the hospital for regular vision examination, to identify myopia or other vision problems timely and receive treatment. Parents should also pay attention to protecting their vision, avoid long-time use of electronic equipment and eliminate poor eye use habits, to set a good example for the children.

Thus, parents should make good efforts in preventing and controlling adolescent myopia, including paying attention to outdoor activities, developing study habits, controlling the use of electronic products, creating a good learning environment, receiving vision examination, adjusting their eating habits, setting a good example. Through such measures, the incidence of adolescent myopia can be effectively reduced and their vision health can be protected.

6.6 Adolescent myopia and academic achievement, mental health and quality of life

This study discusses the influence of myopia on academic achievement, mental health and quality of life of adolescents from the perspective of stakeholders. Through regression analysis, the study found that the years of myopia will have a significant negative impact on individual academic achievement; The degree of myopia has no significant effect on individual academic achievement. This means that with the extension of myopia years, teenagers' academic performance may gradually decline. On the one hand, prolonged close eye activity (such as reading, writing, using electronic products) not only increases the risk of myopia, but also may cause visual fatigue and distraction, thus affecting learning efficiency. On the other hand, teenagers with longer years of myopia may need more visual AIDS (such as glasses or contact lenses) in learning, which may increase the difficulty and inconvenience of learning to a certain extent, and thus have a negative impact on their academic level. However, the degree of myopia itself has no significant effect on the academic level of individuals. This may be because academic attainment is influenced by a variety of complex factors, including but not limited to learning methods, educational resources, family background, and personal intelligence. Under the combined effect of these factors, the degree of myopia may not be the only or the main factor in determining academic level.

The years and degree of myopia have a negative impact on individual mental health. With the increase of years of myopia and the deepening of myopia degree, adolescents may gradually adapt to and accept this condition, but long-term visual discomfort and social pressure may also have a negative impact on their mental health. The years of myopia have a significant negative impact on individual quality of life. With the increase of years of myopia, adolescents may face more visual distress and social pressure, which will reduce their quality of life. First of all, the increase in the number of years of myopia means that teenagers are in a state of visual discomfort for a long time, long-term blurred vision, visual fatigue and other problems will not only affect daily learning and quality of life, but also may gradually accumulate into psychological pressure. In the face of these persistent visual disturbances, adolescents may feel depressed, helpless and even anxious, which may negatively affect their mental health; Second, as myopia increases, adolescents may feel inferior, embarrassed, or insecure in social situations because of vision problems. For example, they may worry that their glasses will affect their appearance, or that they will fall off or be damaged when they exercise. These worries and

anxieties can build up and negatively affect a teenager's confidence and social skills.

A comparison was made with existing studies, the majority of which also focused on adolescent myopia. These studies employed similar methodological approaches, including questionnaire administration and regression analysis, to investigate the potential influencing factors and outcomes. This study examines the impact of adolescent myopia on various stakeholders, including the adolescents themselves, their families, their educational institutions, and their broader social organizations. In contrast, some previous studies have concentrated on the medical effects or biological mechanisms of myopia. In addition, adolescents should assume responsibility for alleviating the current prevalence of myopia or preventing and controlling myopia. Adolescents should cultivate an awareness of their health and engage in behaviors promoting their vision health. They should monitor their vision health status, engage in daily eye care behaviors, perform eye exercises following established norms, and develop an understanding of appropriate eye use. In addition to avoiding prolonged periods of staring at electronic devices and books and resting their eyes at appropriate times, adolescents were advised to participate in eye health training and publicity activities conducted by schools and social organizations to enhance their self-protection awareness. It is recommended that adolescents maintain proper eye posture and ensure that the distance between books and eyes is at least 30 mm when reading or writing. When utilizing electronic devices, the screen should be positioned at a distance of approximately 50-70 mm from the eyes, with a slight downward tilt to prevent direct gaze. Concurrently, the head and neck should be maintained in a natural position, and any prolonged bowing of the head or twisting of the neck should be avoided. It is important to regulate the amount of time spent looking at a screen, particularly when studying or using electronic devices, to prevent prolonged continuous eye use. It is recommended that adolescents engage in at least two hours of outdoor activities on a daily basis. These activities have been shown to relax the eyes and reduce the pressure that can be caused by prolonged close eye use. Moreover, it is beneficial to engage in sports that are beneficial for the eyes, such as table tennis and badminton. These sports enable the eyes to follow the movement of the ball quickly and exercise the eye muscles. This idea is reflected in the study of S. X. Song et al. (2002) : table tennis is effective in improving children's visual acuity because the eyes need to follow the fast-moving ball closely when playing the game, which helps to exercise the eye muscles and improve the flexibility and adjustment of the eyeballs. Outdoor activities are associated with light exposure, and there is also an association between light exposure and myopia in children and adolescents. Outdoor activities and sports can increase light exposure and help prevent myopia. During exercise, the ciliary muscle and lens of the eye are exercised,

which helps to improve blood circulation in the eye and improve visual function (P. F. Zhou et al., 2022).

Recent medical studies have shown that unbalanced diet and excessive intake of sugar in the diet, all of which increase the onset of myopia, are also important factors in inducing myopia in adolescents (Z. K. Yang et al., 2008). This point of view was proved by the study of H. Li et al. (2020), pointed out that adolescents who were picky eaters, had a sweet tooth, and disliked roughage and carrots had a higher rate of visual abnormalities. Therefore, an adequate dietary intake of vitamins and minerals, including calcium and zinc, is recommended. These include carrots, spinach, blueberries, eggs, and other food sources that have been shown to benefit eye health. Should vision loss or other issues be identified, adolescents should inform their parents and take appropriate corrective action. In their daily lives, adolescents should ensure that they obtain sufficient sleep, which will allow their eyes to rest and recuperate adequately. Concurrently, it is advisable to adhere to a regular schedule and refrain from staying up late and engaging in prolonged visual activities. Furthermore, the practice of learning and persistently performing eye exercises can assist in alleviating eye fatigue and tension. This is based on the basic theories of traditional Chinese medicine, such as massage, meridians, etc. Eye exercises mainly adjust the blood circulation of eyes and head by massaging eye points, so as to achieve the functions of adjusting eye muscles, improving eye fatigue and preventing myopia (Guan, 2022).

In the study of adolescent myopia, hospitals, primary and secondary schools, governments, social organizations, families and individuals do not exist in isolation, and all subjects can work together to prevent and control adolescent myopia through complex interaction. For example, the interaction between the government and hospitals is reflected in that the government guides hospitals to provide high-quality and accessible myopia prevention and control services by formulating medical policies, such as increasing the scope of medical insurance reimbursement, and hospitals provide professional advice and data support to the government by participating in policy formulation and implementation, helping the government optimize policy design. In terms of capital budget, the hospital may need to establish a special fund to allocate funds in advance according to the forecast results to ensure that resources are in place in time; The government can adjust the budget allocation mechanism to support the hospital's advance planning and ensure the adequate and efficient use of prevention and control resources. In short, the interaction between stakeholders has a far-reaching impact on the prevention and control of myopia among adolescents. By strengthening the cooperation and communication between subjects, we can form a joint force and improve the prevention and control effect; On the other

hand, if there is insufficient interaction or obstacles, it may lead to waste of resources and poor results. Therefore, future research and practice should focus on how to optimize the interaction mechanism between subjects and build a collaborative and efficient myopia prevention and control system.

Chapter 7: Conclusions and Outlook

7.1 Conclusions

This study employs stakeholder theory to identify key stakeholders closely associated with adolescent myopia and proposes quantitative measures for these entities. Data were collected through field surveys utilizing a structured questionnaire and interview protocol, with Dalian City as the focal point. Together with public data, the study data were analyzed using Granger causality test, regression analysis, and other statistical methods, to reveal the socioeconomic impacts of adolescent myopia. The results will contribute to targeted measures for myopia prevention and control to alleviate the current situation of myopia in adolescents and promote the development of individuals and society. The following conclusions are brought out:

(1) Stakeholders involved in adolescent myopia are clarified, including hospitals, governments, schools, social organizations, individuals, families and other subjects. Quantitative measures for the subjects are presented, including hospitals' investment in medical resources, government's health policies and vision health investment, schools' investment in myopia prevention and control materials, social organizations' investment in publicity and education on myopia prevention and control, families' medical expenses and lens fitting costs, as well as academic achievement, quality of life and mental health of individuals.

(2) The prevalence of myopia among adolescents exerts a significant positive influence on the hospitals' investment in medical resources, investment in myopia prevention and control materials in primary and secondary schools, and government's health policies and vision health investment. Specifically, the number of adolescents with myopia shows a significant impact on the hospitals' investment in medical resources, on the investment in myopia prevention and control materials in primary and secondary schools, and on government's health policies and vision health investment, statistically significant at 5% confidence interval when the lag period is 1 year.

(3) The years of myopia have a significant negative impact on individual academic achievement and quality of life, both of which are significant at 1% confidence interval; The number of years of myopia has a significant negative effect on mental health and lens fitting costs, which is significant at 5% confidence interval, indicating that the increase of the number

of years of myopia will increase the probability of the decrease of academic achievement, quality of life and mental health. The degree of myopia has a significant negative impact on mental health. Compared with moderate myopia and severe myopia, the significance of mild myopia is p=0.072 <0.1, which has statistical significance. The OR value of mild myopia is 0.293 <1, indicating that the increase of myopia degree will increase the probability of decreasing mental health level. The degree of myopia has a significant positive impact on the lens fitting costs. Among them, the significance of moderate myopia is p=0.029 <0.05 compared with mild myopia and severe myopia, and the OR value of mild myopia is 2.032 >1, indicating that the increase of myopia degree will increase the probability of increasing lens fitting costs.

7.2 Theoretical contributions and management implications

7.2.1 Theoretical contribution

Based on stakeholder theory, this paper explores the socioeconomic impact of adolescent myopia, clarifies the stakeholders related to adolescent myopia, further expands and enriches the research boundaries in this field, thereby offering a novel perspective for examining the broader social and economic impacts of adolescent myopia.

Clear the variable measurement indicators of various stakeholders, establish the relationship between adolescent myopia and various stakeholders, clarify the occurrence time limit of the influence relationship, and build a theoretical model of the social and economic impact of adolescent myopia at the social, family and individual levels, providing theoretical basis for stakeholders to proactively study and implement preventive and coping strategies.

7.2.2 Management enlightenment

The influence relationship and time limit of adolescent myopia on hospitals, schools and governments revealed by the research provide management support for relevant departments to make plans in advance and formulate precise management policies. In recent years, the number of young people with myopia has increased rapidly, and the social and economic impact has become increasingly prominent. If everything is ready in advance, it will be lost. Relevant stakeholders such as hospitals, governments and schools can make use of the influence relationship between the two, and make relevant budget and management plans in time within

the influence period based on the dynamic data evolution trend of young people with myopia.

Make use of the influence of the research on the individual and family of adolescent myopia, and carry out preventive coping strategies such as adolescent academic level and mental health counseling in advance. On the one hand, we should attach great importance to the negative impact of myopia on teenagers' academic level and mental health, continue to pay attention to and guide relevant progress in advance, and reduce the potential impact through academic assistance and psychological counseling. On the other hand, develop a family budget and coping preparation to prevent a hasty response to the subsequent development of myopia.

7.3 Shortcomings and prospects

Due to the limited availability of data on myopia among Chinese adolescents, the time period of the study data was from 2010 to 2022. This resulted in limitations in the lag period analysis of the data. The results of the Granger causality test show that there is no Granger causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control when the lag period is 1 to 3 years. Although the results do not achieve statistical significance in the short-term lag period, they may exhibit significance over a longer time span. In comparison to hospital and school subjects, which are closely associated with myopia, the duration of the response of the number of adolescents with myopia to the social organizations' investment in publicity and education on myopia prevention and control may be longer. Consequently, the lag period may take a longer time to demonstrate a causal relationship. It is anticipated that a significant Granger causality between the number of adolescents with myopia and the social organizations' investment in publicity and education on myopia prevention and control will be demonstrated in a longer lag period. Accordingly, this study will continue to investigate the relationship between the two variables over an extended lag period to determine whether there is a Granger causality.

Due to the constraints of time and effort, this study is limited in its ability to select a representative research sample. The study sample is comprised of adolescents in Dalian City. In the future, it would be beneficial to expand the geographical and diversity of the study sample. At the same time, the model will be further refined in the future, such as introducing and controlling the impact of potential confounding factors such as family income and parental education level on family-related expenses. It is hoped that it can provide a scientific basis for future policy formulation and intervention measures, guide the investment and development of relevant social organizations and institutions in the field of myopia prevention and control

publicity and education, and provide more comprehensive and targeted vision health services for adolescents.

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Annex A: Socioeconomic Impacts of Myopia in Chinese Adolescents

Dear students:

Thanks so much for taking the time to fill out this questionnaire. The purpose of this questionnaire is to investigate the socioeconomic impact of myopia in adolescents. This questionnaire is completely anonymous, so please read the following questions carefully and answer them according to your actual situation and true feelings. Your feedback will be really useful for our future academic research. We promise that we'll only use the results of this questionnaire for academic research and that we'll keep your information completely confidential. Thank you so much for your support and cooperation during the research! We wish you all the best in your studies and health!

Part I Basic Information

According to your actual situation, please fill in the blanks or mark " √ " in the corresponding box below. Please fill in this form as carefully as you can, and don't forget to include any information we've asked for. Thanks so much for your support!

1. Your gender is

☐Male ☐Female

2. Your age is ____ years old.

3. Your years of education are _____ (counting from the first year of primary school).

Part II Survey on Myopia in Adolescents

4. Do you suffer from myopia?

☐ Yes ☐ No ☐ Not sure

5. If you have myopia, where were you diagnosed?

☐Hospital ☐Optician ☐School vision screening ☐Subjective feeling of myopia

6. If you are already myopic, the degree of myopia in your right eye is approximately

☐ Less than 300 degrees ☐ 300 to 600 degrees ☐ More than 600 degrees

7. If you are already myopic, the degree of myopia in your left eye is approximately

☐ Less than 300 degrees ☐ 300 to 600 degrees ☐ More than 600 degrees

8. If you are already myopic, what do you think is the main reason for your myopia?

☐ Heredity ☐ Poor eye use habits ☐ Heavy study load ☐ Overuse of electronic products ☐ Others (please specify) _____

9. If you are already myopic, it has been _____ years since you were diagnosed with myopia.

10. If you are already myopic, you expect your myopia to be controlled at _____

☐ As small degrees as possible ☐ 300 degrees or less ☐ 600 degrees or less ☐ Doesn't matter

11. Your purpose of preventing and controlling myopia is to

☐ Apply for special majors ☐ Avoid passing on to next generation ☐ Avoid complications of high myopia ☐ Avoid inconvenience of wearing glasses ☐ Follow parents' arrangement ☐ I don't know ☐ Others (please specify) _____

Part III Survey on the Cost of Myopia in Adolescents at the Social Level

12. If you are already myopic, have you taken appropriate myopia prevention and control measures?

☐Yes ☐No

13. If you are already myopic, the reason for not taking myopia prevention and control measures is

☐ High cost ☐ No time ☐ Able to see clearly ☐ Parents against myopia ☐ Others (please specify) _____

14. If you have taken myopia prevention and control measures, the methods currently used are (check all that apply) _____

☐ Spectacle ☐ Peripheral defocus spectacle ☐ Orthokeratology lens ☐ Peripheral defocus soft contact lens ☐ Low concentration of atropine eye drops ☐ Low-level laser therapy ☐ Eye-care lamp ☐ Visual function training ☐ Visual distance extender ☐ Chinese medicine acupoint massage

☐ Others (please specify) _____

15. If you wear spectacles, the price range of your last purchase of spectacles with frames and lenses was

☐ Within RMB 1,000 ☐ RMB 1,000-2,000 ☐ RMB 2,000-3,000 ☐ RMB 3,000-4,000 ☐ RMB 4,000-5,000 ☐ RMB 5,000 and above

16. If you wear spectacles, how often do you change your spectacles on average?

☐ Within 1 year ☐ 1-1.5 years ☐ 1.5-2 years ☐ 2-3 years ☐ 3 years and above

17. If you wear orthokeratology lenses (including care products), the cost for one year is about

☐ Within RMB 8,000 ☐ RMB 8,000 - RMB 10,000 ☐ RMB 10,000 - RMB 12,000 ☐ RMB 12,000 and above

18. If you also take myopia prevention and control measures other than spectacles and orthokeratology lenses, the average annual expenditure on products is

☐RMB 1,000-2,000 ☐RMB 2,000-3,000 ☐RMB 3,000-4,000 ☐RMB 4,000-5,000

☐ RMB 5,000 and above

19. Over the past year, how many times did you visit ophthalmologists or opticians for a myopia review?

☐ None ☐ 1-2 times ☐ 3-4 times ☐ 5-6 times ☐ More than 6 times

20. Over the past year, the cost of a single visit to an ophthalmologist or optician for myopia review was about

☐ Within RMB 100 ☐ RMB 100-200 ☐ RMB 200-400 ☐ RMB 400-600 ☐ RMB 600-800

☐ RMB 800-1,000 ☐RMB 1,000 and above

21. Over the past year, the transportation cost for a single round trip to the ophthalmologist or optician for myopia review was about

☐ Within RMB 100 ☐ RMB 100-200 ☐ RMB 200-300 ☐ RMB 300-400

☐ RMB 400-500 ☐ RMB 500 and above ☐ No cost

22. Over the past year, the total labor hours lost for all the accompanying persons attending the ophthalmologist or optician for myopia review is (labor hours lost = current hourly wage * time spent, accumulated for multiple accompanying persons)

☐ Within RMB 200 ☐ RMB 200-400 ☐ RMB 400-600 ☐ RMB 600-800

☐ RMB 800-1,000 ☐ RMB 1,000 and above ☐ No cost

23. The treatment cost you spent in hospitals or other organizations for myopia treatment (e.g., laser surgery) was

☐ Within RMB 10,000 ☐ RMB 10,000-20,000 ☐ RMB 20,000-30,000 ☐ RMB 30,000-40,000 ☐ RMB 40,000+

24. Who pays for your myopia-related expenses, including products to prevent and control myopia, regular check-ups and treatment-related expenses?

☐ Family ☐ Government ☐ Both ☐ Others _____

Part IV Individual-level Cost Survey on Myopia in Adolescents

25. Your annual household income range is

☐ Less than RMB 10,000 ☐ RMB 10,000-RMB 30,000 ☐ RMB 30,000-RMB 80,000 ☐ RMB 80,000-RMB 150,000 ☐ RMB 150,000-RMB 300,000

☐ RMB 300,000-1,000,000 ☐ RMB 1,000,000 and above

26. How do you think myopia affects your social activities?

☐ Significant ☐ Major ☐ Not sure ☐ Minor ☐ None

27. How do you think myopia affects your schoolwork?

☐ Significant ☐ Major ☐ Not sure ☐ Minor ☐ None

28. Your average grade in major subjects according to the results of the final examination of the school year is

☐ 90 or above ☐ 80-90 ☐ 70-80 ☐ 60-70 ☐ Below 60

29. How many days in the past week did you feel depressed?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

30. How many days in the past week did you feel like you were struggling to do anything?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

31. How many days in the past week did you have trouble sleeping?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

32. How many days in the past week did you feel lonely?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

33. How many days in the past week did you feel sad?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

34. How many days in the past week did you feel unable to devote yourself to your studies?

☐ Most of the time (5-7 days) ☐ Often (3-4 days) ☐ Some of the time (1-2 days) ☐ Hardly ever (less than a day)

Annex B: Interview Outline - Investment in Myopia Prevention and Control Materials in Primary and Secondary Schools

1. What equipment and materials have your school invested in to prevent and control myopia? (e.g., materials needed for vision screening and eye exercises, vision training equipment, promotional materials for vision health education, appropriate desks and chairs, clear and eye-friendly teaching aids, eye-friendly teaching materials that meet health standards, and other related materials, etc.)

2. What is the total value of materials invested in myopia prevention and control materials in your school? (It is better to have the data or general trend for each of the last 10 years).

3. Does your school have a maintenance schedule for the equipment? What is the estimated cost?

4. Does your school have plans to introduce new equipment and materials to improve the effectiveness of myopia prevention and control? If so, what is the budget for the investment?