Cost-effectiveness of myopia control by use of defocus incorporated multiple segments lenses: abridged secondary publication

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KEY MESSAGES

1. Myopia control by use of defocus incorporated multiple segments lenses can prevent eye complications and severe visual impairment and is cost-effective from the societal perspective in terms of cost per quality-adjusted life year gained.
2. It is cost-effective for the government to subsidise myopia control and improve equity of access for defocus incorporated multiple segments lenses.

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Introduction

Myopia is the most common eye condition worldwide. Its prevalence is projected to increase from 23% to 50% of the global population between 2000 and 2050, and the global prevalence of high myopia is projected to increase from 2.7% to 9.8% over same period.[1] Hong Kong has an alarmingly high prevalence of myopia, particularly among school children: 18.3% of 6-year-olds are myopic, and the prevalence rises to almost 70% by age 17. High myopia can cause severe visual impairment due to ocular complications, including myopic macular degeneration, retinal detachment, glaucoma, and cataract. Many of these conditions cause irreversible vision loss. The socioeconomic impact of myopia is reflected in decreased quality of life and increased costs for individuals, public health care systems, and society related to care for ocular complications and visual loss.

Because the school years often exhibit the fastest myopia progression, this time period is crucial for myopia control. Various interventions have been developed to control myopia progression, including optical interventions (eg, spectacle lenses, soft contact lenses, and orthokeratology) and pharmacological interventions.[2-5] Orthokeratology has been routinely used for more than a decade in Hong Kong, and it reportedly reduces myopia progression by >40% if applied at the appropriate time.[4] Locally developed defocus incorporated multiple segments (DIMS) lenses constitute the latest spectacle design for myopia control. The efficacy of DIMS lenses in reducing myopia progression is 52%.[2] These lenses are easy to use and non-invasive and thus are potentially eligible for most people. Despite upfront costs, myopia control has potential benefits of avoiding vision loss related to high myopia-associated ocular complications, thereby improving quality of life.

The aim of this study was to evaluate the cost-effectiveness of myopia control through the use of DIMS lenses in children. We built a cost-effectiveness model to estimate the quality-adjusted life years (QALYs) gained and costs over a lifetime for myopia control, to conduct sensitivity and value of information analyses to quantify uncertainty in results and the value of reducing this uncertainty, and to examine cost-effectiveness from the perspectives of public health care, patients, and society.

Methods

A cost-effectiveness analysis was conducted to determine (1) whether myopia control is value for money from a societal perspective and (2) whether it is cost-effective for the government to subsidise myopia control to enable equitable access. We first compared the strategies of myopia control with 100% uptake versus no myopia control. This fairly reflects whether myopia control is value for money when financial barriers in uptake are absent and access is provided to all eligible children. We then compared the strategies of myopia control fully subsidised by the government with 80% uptake versus the current status quo, without subsidy, with 10% uptake.

An individual-based Markov state-transition model was developed based on the natural history of myopia development and progression. Individuals began with an initial level of myopia (none, mild, moderate, or high) and could progress to a higher level, develop myopia-related eye diseases, and eventually exhibit severe visual impairment (visual acuity <20/200). A cycle length of 1 year was used, and transitions between health states were simulated in each cycle over an individual's lifetime. Myopia control interventions were incorporated into the natural disease progression to simulate how the receipt of myopia control in childhood affects progression to high myopia, thereby preventing sight-threatening eye diseases later in life. This model was developed using TreeAge Pro Suite 2020 (TreeAge Software, Inc, Williamstown, MA, USA).

The model simulated an individual's health states in childhood and adulthood. Phase 1 began with individuals randomly assigned to various ages (6 to 11 years), either sex, and various levels of myopia in terms of spherical equivalent refraction. Beginning in the first cycle, annual changes in spherical equivalent refraction were applied to individuals according to age, myopia level, and treatment status. For a myopic individual who received myopia control, smaller annual changes in spherical equivalent refraction were applied. The development and progression of myopia were simulated until age 18, when the myopia level became stable.

Phase 2 simulated the impact of myopia on the development of retinal detachment, myopic macular degeneration, cataract, and open-angle glaucoma. The annual transition probabilities of the diseases were applied at age 50. The development of each disease was simulated until the individual reached age 100 years, exhibited severe visual impairment, or died. Individuals with myopia, particularly high myopia, had higher probabilities of developing eye diseases. After the development of any eye disease, impact on vision was further simulated. The progression and decision pathways for each eye disease were simulated independently, and more than one disease could develop over an individual's lifetime.

In each cycle, utility decrement values were assigned based on the largest decrement among disease states that an individual could have. Individuals with severe visual impairment from any eye disease were not included in further simulations of other eye diseases, and the utility decrement for severe visual impairment was assigned to their remaining lifetime.

Lifetime costs and benefits were calculated and compared. Incremental cost-effectiveness ratios (ICERs) were calculated and compared with the willingness to pay (WTP) threshold for a QALY. All future costs and QALYs were first reported with no discount and then with a 3.5% discount rate on costs but no discount on QALYs (0%). We tested a 3.5% discount rate for QALYs in the scenario analysis. According to the World Health Organization (WHO)–recommended threshold, a 1-QALY gained is very cost-effective for up to 1 × annual gross domestic product (GDP) per capita (HK$377 165 in Hong Kong, 2019) and cost-effective for up to 2 × GDP. We conducted sensitivity analysis to determine how uncertainties regarding the parameters influenced cost-effectiveness.

Results

The cumulative prevalence of moderate myopia was 38.6% lower when using DIMS lenses than when not using myopia control (20.5% vs 33.3%), and the cumulative prevalence of high myopia was 47.9% lower (5.9% vs 11.3%), whereas the proportion of individuals who developed any complication of retinal detachment, myopic macular degeneration, or open-angle glaucoma was 14.3% lower (13.8% vs 16.1%), and the proportion with severe visual impairment was 17.5% lower (2.7% vs 3.3%).

With no discount on costs, use of DIMS lenses was cost-saving compared with no myopia control. Using a 3.5% discount rate on costs, the difference in incremental costs between DIMS lenses and no myopia control was HK$9913 (HK$57 850 vs HK$47 937) and difference in incremental QALYs gained was 0.19 (72.78 vs 72.59); thus, the ICER of myopia control was HK$52 792 per QALY gained. Using a 3.5% discount rate on QALYs, the ICER of myopia control was HK$181 794 per QALY gained. In probabilistic sensitivity analysis, myopia control using DIMS lenses had >50% probability of being cost-effective when the WTP for a QALY was ≥HK$35 000; the probability of being cost-effective was 79% when the WTP reached the WHO-recommended threshold of HK$377 165. One-way sensitivity analysis showed that the five parameters with the greatest impact on the ICER were utility decrements on mild, moderate, and high levels of myopia, cost of DIMS lenses, and effectiveness of DIMS lenses. However, all ICERs (up to HK$146 120) across the test range of these parameters' values were within the WHO-recommended threshold.

From a government perspective, when only costs were discounted at 3.5%, the difference in incremental cost between myopia control with subsidy and myopia control with no subsidy was HK$8701 (HK$11 905 vs HK$3204), and the incremental QALYs gained was 0.15 (72.77 vs 72.61). Thus, the ICER was HK$56 797 per QALY gained. Probabilistic sensitivity analysis showed that myopia control with subsidy had >50% probability of being cost-effective when the WTP for a QALY was ≥HK$43 000; the probability of being cost-effective was 72% when the WTP reached the WHO-recommended threshold of HK$377 165. When QALYs gained were discounted at 3.5%, the ICER was HK$209 000 per QALY gained.

Discussion

The model demonstrated that myopia control by use of DIMS lenses can potentially reduce the development of any complications of retinal detachment, myopic macular degeneration, and/or open-angle glaucoma) by 14.3% and the development of severe vision impairment (visual acuity worse than 20/200) by 17.5% over a lifetime. The cost per individual spent on DIMS lenses was HK$9913 more after subtracting future savings gained (through avoiding more expensive spectacles for severe myopia, greater health care utilisation, increased patient time spent in treatment and follow-up for eye complications, and productivity loss secondary to severe vision impairment). Using the WHO-recommended threshold of HK$377 165 per QALY, use of DIMS lenses was cost-effective with an ICER of HK$52 792 per QALY gained. When the discount rate for QALYs was 3.5%, the ICER increased (HK$181 794) but remained below the WHO-recommended threshold for cost-effectiveness. From a government perspective, subsidising DIMS lenses was cost-effective with ICERs below the WHO-recommended threshold.

Conclusion

Myopia control by use of DIMS lenses is potentially cost-effective for society. A government-subsidised programme could be a cost-effective option to improve equity of access.

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