

# Direct Costs of Myopia in India

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## Research Article

**Keywords:** Myopia, Expenditure, Economic burden, Indian population, Direct costs

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## **PURPOSE**

This study aimed to estimate the direct costs of myopia among subjects from India.

## **METHODS**

An observational study on direct costs of myopia among subjects aged between 6 and 40 years with spherical equivalent (SEQ) refraction of at least -0.50 D was conducted. Subjects were recruited from the five units of myopia management in the country, namely, regular chains, institutions, individual practitioners, wholesalers and online. A semi-structured questionnaire comprising the cost of spectacles, consultation, transportation, and frequency of visits to eye care professionals and changes in spectacles was used. Data were analysed to report the median annual cost of myopia and comparison between different degrees of myopia.

## **RESULTS**

A total of 335 subjects participated across the five units. The median age was 25.0 years (IQR: 19.0 years, 31.0 years) and the median SEQ was -3.25 D (IQR: -1.75 D, -5.50 D). The median annual direct cost of myopia was INR 4,600.00 (IQR: INR 2,300.00, INR 9,395.00) [US\$ 62.16 (IQR: US\$ 31.08, US\$ 126.95)] with median cost of spectacles contributing to 72.8% of the total cost. There was a statistically significant difference in the annual direct costs with varying degrees of myopia ( $p < 0.001$ ) and units of myopia management ( $p < 0.001$ ).

## **CONCLUSIONS**

The study reports the annual direct costs of myopia which is more than 5% of an average per capita income in India. Strategies are needed to reduce burden of myopia correction on individuals.

**Keywords:** Myopia, Expenditure, Economic burden, Indian population, Direct costs.

## **INTRODUCTION**

Myopia is widely recognized as a public health issue causing significant visual loss and a risk factor for a range of other serious ocular conditions [1] including retinal detachment, optic disc abnormalities, cataract formation and glaucoma [2]. Global prevalence of myopia is about 34% of the total population and is estimated to be nearly 50% by year 2050 [3]. In India, the prevalence of myopia in children  $\leq 15$  years of age is 5.3% [4] and in adults  $\geq 30$  years of age is 27.7% [5]. With such huge prevalence of myopia, studies have quoted global productivity loss due to uncorrected myopia at US\$ 244 billion [6]. While economic burden from the country's perspective is available on one side, the burden on an individual as a direct cost of myopia is reported in very few studies. Two studies are reported from Singapore, that estimated mean annual direct costs of myopia among children and adults to be US\$ 147.8 [7] and US\$ 709 [8] respectively.

The reported increasing trend of myopia [9] would consequentially increase the number of myopes in India. To date, spectacles and contact lenses are the primary treatment options for myopia. Orthokeratology and Laser-assisted in situ keratomileusis (LASIK) or Photorefractive keratectomy (PRK) are other treatment options for correcting myopia [10]. In India, the cost of comprehensive eye examination and also the cost of correction of the refractive error such as myopia are not covered by health insurance. Apart, the spectacle frames and lenses are not listed as medical devices [11]. Hence, the costs are directly borne by the patient to meet the required visual demand. There are no studies that report the estimates of cost spent by myopes on their management. This study aims to estimate the direct annual costs borne by the myopic population from India.

## **MATERIALS AND METHODS**

### **STUDY SUBJECTS RECRUITMENT**

A preliminary study was done to understand the various sources through which myopia management happens in the country. Various units of eye care service delivery included regular chains, institutions, individual practitioners, wholesalers, and online. Data collected from a leading manufacturer and distributor of lenses led us to the distribution of (myopic) lenses as 41% from regular chains, 23% from institutions, 16% from individual practitioners, 4% from wholesalers and 16% from online. Hence subjects who accessed myopia management from any one of the categories were enrolled into the study.

## **DEFINITIONS**

Regular chains are the eye care professionals (ECPs) who have two or more outlets across the cities (or states) under a single brand name. There are approximately 800 regular chains in India [12]. Institutions are the ECPs who are associated with tertiary eye care centres. Individual practitioners are ECPs who are associated with a single clinical outlet. India has hospitals either set up as part of a chain, as an individual private clinic or as subspecialty in a multispecialty hospital counting to approximately 1280 hospitals across the country.<sup>12</sup> Wholesalers are those who dispense spectacles in large quantities at low prices, typically to retailers. Online is the virtual platform used to dispense spectacles.

The subjects were divided into three groups [13] based on the degrees of myopia, namely low myopia [spherical equivalent (SEQ) more than -3.00D], moderate myopia [SEQ between -3.00D and more than -6.00D] and high myopia [SEQ less than -6.00D]. The worse eye was considered for analysis based on the magnitude of myopia.

Subjects between 6 and 40 years of age and those who had SEQ of -0.50D or lesser in either eye were included and subjects with any ocular pathology, aphakia and pseudophakia were excluded from the study. Subjects were recruited from the five categories based on the proportion of distribution of myopic lenses under each category. Various ECPs across the five arms were approached via email/call, informing them about the study. The ECPs' consent was obtained to recruit their patients/customers in the study for an interview to answer a set of questions designed to assess the expenditure on eye care directly relevant to myopia.

Subjects were recruited after obtaining their consent to be a part of the study. If the subject was not available in person, on obtaining oral assent, the interview was done via telephonic conversation. If the subject was below 18 years of age, the interview was taken with their respective parent/guardian. The subjects were asked about estimates of costs of eye care directly associated with myopia in the preceding twelve months.

## **EXPENDITURE QUESTIONNAIRE ON MYOPIA**

Subjects were asked about estimates of costs using a semi-structured questionnaire designed to assess the expenditure on myopia, that is similar to Lim, M.C. et al [7] and Zheng, Y.F. et al [8] studies. The questionnaire included items on the consultation charges to ECPs for the comprehensive eye examination, cost of frame, cost of the lenses, transportation charges for the visit to ECPs, frequency of visits to the ECPs and frequency of change in spectacles in a year. If the subject were a contact lens user, cost of contact lenses and the solution were noted for a year. Subjects were also enquired about any refractive surgery that they have undergone. The

data collected from subjects on the cost of frame and lenses were verified with their respective practitioners to rule out any recall bias.

### **Calculating annual cost**

Annual direct costs for each participant were computed based on the sum of the annual cost of spectacle frames (A), the annual cost of spectacle lenses (B), the annual cost of consultation with ECPs (C) and the annual cost of transportation (D) which was similar to that of Lim, M.C. et al [7].

### **Statistical analysis**

Statistical analysis was carried out using SPSS 20.0, IBM Corp., Armonk, NY, USA. Kolmogorov-Smirnov test was carried out to test the normality of the data. Based on the results, Mann-Whitney test, Kruskal-Wallis test and post hoc test were done to compare between groups and a p-value less than 0.05 was considered statistically significant.

Costs were calculated in INR and converted to US\$ based on an exchange rate of approximately INR 74.00 [14]. The study conformed to the tenets of the Declaration of Helsinki.

## **RESULTS**

Data were collected between November 2020 and June 2021 from the five units of myopia management. Out of the nineteen regular chains approached, eight provided consent to recruit their patients/customers. For the institutions group, three tertiary eye care hospitals (two from southern India and one from the eastern part of India) that provides ophthalmic care to approximately 1,200 patients per day throughout India [15], were centres for recruiting subjects. Among the twenty-two individual practitioners who were approached, thirteen practitioners across Bangalore, Bellary, Chennai, Hyderabad and Kolkata provided consent to recruit their patients. Three wholesalers dispensing spectacle frames and lenses were approached and one from Tamil Nadu agreed to be a part of the study. Lastly, one nationwide online spectacle dispenser was approached and consent was obtained to recruit their customers for the study.

A total of 335 subjects participated in the study. There were 122 subjects (36.4%) recruited from regular chains, 76 subjects (22.7%) from institutions, 49 subjects (14.6%) from individual practitioners, 13 subjects (3.9%) from wholesalers and 75 subjects (22.4%) from online mode. Kolmogorov-Smirnov test showed a significant departure from normality with  $p < 0.001$ .

### **Demographic Characteristics:**

The median age of the subjects was 25.0 years (IQR: 19.0 years, 31.0 years) with a range between 6 and 40 years. The median SER was -3.25 D (IQR: -1.75 D, -5.50 D) with range between -0.50 D and -28.25 D. There were 144 female subjects (43%) and 191 male subjects (57%). There were 67 children (20%) whose median age was 12.0 years (IQR: 7.5 years, 15.0 years).

### **Annual Direct costs among the study participants:**

For 335 subjects, the median annual direct cost of myopia was INR 4,600.00 (IQR: INR 2,300.00, INR 9,395.00) [US \$ 62.16 (IQR: US \$ 31.08, US \$ 126.95)].

There were 308 subjects (91%) who bought a new spectacle frame along with new spectacle lenses, and 27 subjects (8%) were using the older spectacle frame for the new spectacle lenses. The median annual cost of the spectacle frame (Cost A) was INR 1120.00 (IQR: INR 575.00, INR 2,400.00) [US\$ 15.13 (IQR: US\$ 7.77, US\$ 32.43)]. The median annual cost of spectacle lenses (Cost B) was INR 1910.00 (IQR: INR 1,390.00, INR 4,300.00) [US\$ 25.81 (IQR: US\$ 18.78, US\$ 58.10)]. The median cost per pair of spectacles (Cost A+B) was INR 3,350.00 (IQR: INR 2,300.00, INR 6,915.00) [US\$ 45.27 (IQR: US\$ 31.08, US\$ 93.44)].

There were 139 subjects (41.5%) who had no additional charges for the comprehensive eye examination while 196 subjects (58.5%) had consultation charges. The median annual consultation charges (Cost C) were INR 150.00 (IQR: INR 0.00, INR 700.00) [US\$ 2.02 (IQR: US\$ 0.00, US\$ 9.45)]. There were 87 subjects (26%) who had not spent on transportation and 248 subjects (74%) had transportation charges. The median annual transportation charges (Cost D) were INR 200.00 (IQR: INR 0.00, INR 400.00) [US\$ 2.70 (IQR: US\$ 0.00, US\$ 5.40)]. Twelve subjects recruited from institutional unit had come to the tertiary eye care hospital from a different city for the comprehensive eye examination with median annual transportation charges of INR 14,000.00 (IQR: INR 12,400.00, INR 15,310.00) [US\$ 189.18 (IQR: US\$ 167.56, US\$ 206.89)].

A proportion of subjects had multiple consultations and more than a pair of spectacles, which had an impact on the cost. Out of the 335 subjects, 287 subjects (85.7%) visited the ECPs for a comprehensive eye examination at least once in the past year. Forty-one subjects (12.2%) visited twice in the past year. Four subjects (1.2%) visited thrice and three subjects (0.9%) visited four times in the past year. Among the 335 subjects, 308 subjects (91.9%) changed their spectacles at least once in the past year. Twenty-four subjects (7.2%) had changed their

spectacles twice in one year. Two subjects (0.6%) changed the spectacles thrice and one subject (0.3%) changed spectacles four times in a year due to a change in refractive error.

There were fifty-two subjects (15.5%) who bought contact lenses along with the pair of spectacles. Among the contact lens wearers, four wore daily disposable lenses (7.7%), Forty-six wore monthly disposable lenses (88.5%), and two wore quarterly disposable lenses (3.8%). The median annual cost of contact lenses and its solution among the fifty subjects was INR 6,805.00 (IQR: INR 5262.50, INR 10,017.50) [US\$ 91.95 (IQR: US\$ 71.11, US\$ 135.37)]. None of the 335 subjects reported to have undergone any form of refractive surgery to correct myopia.

### **Annual direct cost across different variables**

The median annual direct cost of female and male subjects was INR 4,800.00 (IQR: INR 2,300.00, INR 9,396.25) [US\$ 64.86 (IQR: US\$ 31.08, US\$ 126.97)] and INR 4,550.00 (IQR: INR 2,300.00, INR 9,042.50) [US\$ 61.48 (IQR: US\$ 31.08, US\$ 122.19)] respectively. Mann-Whitney test revealed that there was no statistical difference between male and female groups for the annual direct expenditure,  $p = 0.402$ .

There were 140 subjects who had low myopia (41.8%) with a median annual direct cost of INR 2,812.50 (IQR: INR 2,291.25, INR 7,911.75) [US\$ 38.00 (IQR: US\$ 30.96, US\$ 106.91)], 118 subjects had moderate myopia (35.2%) with median annual direct cost of INR 4,565.00 (IQR: INR 2,300.00, INR 8,070.00) [US\$ 61.68 (IQR: US\$ 31.08, US\$ 109.05)] and 77 subjects had high myopia (23%) with median annual direct cost of INR 7,690.00 (IQR: INR 4,550.00, INR 11,870.00) [US\$ 103.91 (IQR: US\$ 61.48, US\$ 160.40)]. The Kruskal-Wallis H test showed that there was a statistically significant difference in the annual direct costs with varying degrees of myopia,  $H(2) = 33.727$ ,  $p < 0.001$ . Further post hoc analysis revealed that there was no statistical significance in the annual direct costs between the low and moderate degree of myopia ( $p = 0.171$ ), whereas there was a statistically significant difference in the annual direct costs between the low and high degree of myopia ( $p < 0.001$ ), and between the moderate and high degree of myopia ( $p < 0.001$ ).

The median annual direct cost across the myopia management units was analysed. Subjects recruited from regular chains had annual median direct cost of INR 5,565.00 (IQR: INR 3,138.75, INR 11,405.00) [US\$ 75.20 (IQR: US\$ 42.41, US\$ 154.12)]. Among the subjects recruited from institutions, the median annual direct cost was INR 7,960.00 (IQR: INR 5,310.00, 12,498.75) [US\$ 107.56 (IQR: US\$ 71.75, US\$ 168.90)]. Subjects recruited from individual practitioners had median annual direct cost of INR 5,600.00 (IQR: INR 3,500.00, INR 10,040.00) [US\$ 75.67 (IQR: US\$ 47.29, US\$ 135.67)]. The subjects recruited from wholesalers had median

annual direct cost of INR 2,580 (IQR: INR 1,910.00, INR 3,300.00) [US\$ 34.86 (IQR: US\$ 25.81, US\$ 44.59)]. Subjects recruited from those who purchased spectacles online had a median annual direct cost of INR 2,300.00 (IQR: INR 1,800.00, INR 2,300.00) [US\$ 31.08 (IQR: US\$ 24.32, US\$ 31.08)]. Kruskal-Wallis H test showed that there was a statistically significant difference in the annual direct costs between the ECPs,  $H(4) = 137.686$ ,  $p < 0.001$ . Further post hoc analysis revealed that there was a statistically significant difference in the direct costs between online and all other myopia management units ( $p < 0.001$ ) except wholesale purchase ( $p = 1.000$ ). Similarly, there was a significant difference in the costs when wholesale purchase was compared with institutional purchase ( $p < 0.001$ ) and regular chain purchase ( $p = 0.007$ ). There was no difference in the costs incurred between the other myopia management units.

There were 67 children aged 6-17 years with annual median direct cost of INR 6,120.00 (IQR: INR 4,060.00, INR 10,570.00) [US\$ 82.70 (IQR: US\$ 54.86, US\$ 142.83)] and 268 subjects (80%) were adults aged 18-40 years with annual median direct cost of INR 3,940.00 (IQR: INR 2,300.00, INR 8,902.50) [US\$ 53.24 (IQR: US\$ 31.08, US\$ 120.30)]. Mann-Whitney test revealed that there was a statistically significant difference between the two age groups for the annual direct expenditure, ( $p < 0.001$ ). Further categorisation of different age group of children showed the annual median direct cost to be INR 7,899.00 (IQR: INR 5,620.00, INR 12,690.00) [US\$ 106.74 (IQR: US\$ 75.94, 171.48)] among children aged 6-10 years ( $n=25$ ), INR 5,627.50 (IQR: INR 4,070.00, INR 9,940.00) [US\$ 76.04 (IQR: US\$ 55.00, US\$ 134.32)] among children aged 11-15 years ( $n=30$ ), and INR 4,060.00 (IQR: INR 3,625.00, INR 7,080.00) [US\$ 54.86 (IQR: US\$ 48.98, US\$ 95.67)] among children aged 16-17 years ( $n= 12$ ). The summary of the results are depicted in Table 1.

**Table 1:**Table Summarizing annual direct costs of myopia of participants.

<b>Category</b>	<b>Subcategory</b>	<b>n</b>	<b>Median Annual Cost (US\$)</b>	<b>IQR (US\$)</b>	<b>p value</b>
<b>All</b>		335	62.16	31.08 126.95	
<b>Gender</b>					0.402
	Female	144	64.86	31.08 126.97	
	Male	191	61.01	31.08 122.19	
<b>Degree of Myopia</b>					< 0.001*
	Low	140	38.00	30.96 106.91	
	Moderate	118	61.68	31.08 109.05	
	High	77	103.91	61.48 160.40	
<b>Myopia Management units</b>					< 0.001*
	Regular chains	122	75.20	42.41 154.12	
	Institutions	76	107.56	71.75 168.90	
	Individual Practitioners	49	75.67	47.29 135.67	
	Wholesalers	13	34.86	25.81 44.59	
	Online	75	31.08	24.32 31.08	
<b>Age</b>					< 0.001*
	Children	67	82.70	54.86 142.83	
	Adults	268	53.24	31.08 120.30	

\* Statistically Significant

## DISCUSSION

The study reports annual direct costs of myopia from diverse units of myopia management in India. The median cost from our study, INR 4,600.00 [US \$ 62.16] is almost less than three-fourth of the median cost estimated for children by Lim, M.C. et al [7] and ten times lesser compared to the cost estimates for adults by Zheng, Y.F. et al [8]. Though the cost for myopia correction in India is significantly less, the median annual cost of myopia is more than 5% of the estimated average per capita income in India at INR 86,659.00 [16] [US\$ 1,171.06]. The annual minimum wage is approximately INR 54,900.00 [17] [US\$ 741.89] and the correction of myopia amounts to more than 8% of the income. This is a significant burden considering that the health care in India is based on 'out-of-pocket' expenses predominantly.

In this study, refractive correction i.e. cost of a pair of spectacles accounted for 72.8% of the total annual costs. This was higher compared to Zheng, Y.F. et al [8] study whose refractive correction accounted for 65.2% of the total costs [8]. Cost of spectacle frames ranged from as low as INR 200.00 [US\$ 2.70] to as high as INR 24,995.00 [US\$ 337.77], these variation in cost could be noted as expensive frames may be purchased for cosmetic reasons. The remaining 27.2% of the total expenses were because of consultation and transportation charges. Regular chain and individual practitioners provided complimentary eye examination on the purchase of spectacles. While most of the subjects from these units did not have any expenses on the consultation charges, subjects preferring comprehensive eye examination visited tertiary eye centres that added to the consultation charges. Subjects from different parts of the country coming to tertiary eye care centres for comprehensive eye evaluation had an increase in transportation charges compared to those who had a comprehensive eye examination at a local place, this is because of the long distances travelled to get access to an eye examination. One of the possible reasons for visiting far distance could be due to the lack of availability of facilities such as comprehensive ophthalmic examination at their respective places. These subjects also borne additional cost of stay at hotel rooms. Subjects who bought via online platform had no transportation charges as well, because their spectacles were delivered doorstep.

The other finding from the study was that the annual direct costs increased with the higher degree of myopia. As refractive error increases, myopes tends to choose higher refractive index lenses to reduce the overall thickness of the lenses, which are costlier than low refractive index lenses. In addition, complication arising from contact lens usage or post LASIK, could add up to the annual expenses. However, none of the subjects reported any such complications. Also, high myopic patients may undergo additional diagnostic tests such as ocular imaging

devices including optical coherence tomography, ultrasound, and magnetic resonance imaging to enable visualization of pathological changes [18]. These procedures would again involve additional expenses. The scope of this study was limited to reporting cost of myopia from the perspective of optical management. The study can be extended further to understand holistic management of myopia care.

In our study, the median annual direct cost of myopia among all subgroups of children is more compared to adults. This could be because of children having multiple visits for the comprehensive eye examination and/or purchase of polycarbonate lenses for better protection, that added to the cost.

The total direct cost for the Indian population [19,20] was extrapolated by applying the median annual direct cost among children and adults to their respective myopia prevalence [4,5] in the population of the country. The cost of myopia was estimated to be at least INR 183 billion [US\$ 2.5 billion] and INR 866 billion [US\$ 11 billion] among children and adults respectively per year in India. Because of the high number of myopes based on the population and prevalence estimates, the total cost of myopia for the country far outweighs the total cost of the country from the Singaporean study [8].

Prospective research should focus on including the cost of myopia prevention strategies. The costs of correcting myopia are high, efforts are to be focused on the prevention of myopia and to slow the progression of myopia. Interventions [21,22] may help slower myopic progression. The cost-effectiveness of these interventions needs to be assessed and ensured that these costs are not higher than the benefits it provides.

Considering the burden on individuals, policies on insurance claims especially for spectacle management of high myopia would be beneficial. Another overarching benefit would be to include spectacles as medical devices and reduce the associated tax thereby reducing the burden on individuals. Further studies need be done including the indirect costs borne by the myope, such as lost workdays for a comprehensive eye examination, cost associated with the accompanying person to fully understand the economic burden caused due to myopia.

In summary, the study shows the annual median direct cost for a myope is INR 4,600.00 (IQR: INR 2,300.00, INR 9,395.00) [US \$ 62.16 (IQR: US \$ 31.08, US \$ 126.95)]. This cost is huge considering the average per capita income in India and warrants strategies that would make the cost affordable.

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### **Competing Interests**

The authors have no relevant financial or non-financial interests to disclose.

### **Author Contributions**

All authors contributed to the study conception and design. Material preparation was performed by Viswanathan Sivaraman, Aparna Gopalakrishnan and Sachin Singh. Data collection was performed by Sachin Singh, Janarthanam Jothi Balaji and Viswanathan Sivaraman. Data analysis was performed by Sachin Singh, Aparna Gopalakrishnan and Anuradha Narayanan. The first draft of the manuscript was written by Sachin Singh and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

### **Ethics approval**

This is an observational study. The Institutional Review Board has confirmed that no ethical approval is required.

### **Consent to participate**

Informed consent was obtained from all individual participants included in the study and for participants below eighteen years, consent was obtained from the parents.