# The economic burden of diabetic retinopathy care at a tertiary eye care center in South India

*Andrea Orji, Padmaja K Rani[1], Raja Narayanan[1], Niroj K Sahoo[1], Taraprasad Das[1]*

**Purpose:** The aim of this study was to analyze the cost and factors affecting diabetic retinopathy (DR) care in a tertiary eye care facility in South India. **Methods:** In a retrospective, observational study, we evaluated the costs incurred in DR management in each stage of retinopathy from electronic medical records. Both medical and indirect costs (transportation and boarding) were calculated. **Results:** The study evaluated 1000 consecutive patients (2000 eyes) with DR, from January to June 2019. One-third (32%; *n* = 321) patients were females. The median cost per patient was INR 8,214 (IQR 2,812-29,748). Cost of care was higher in patients with sight-threatening DR (STDR) compared to non-STDR (INR 31,820 vs INR 14,356, *P* < 0.001). Among 57.3% (*n* = 573;1137 eyes) of subjects who completed treatment, there was a statistically significant reduction in visual impairment (427 to 355 eyes) and blindness (<3/60) (132 to 103 eyes) from baseline (*P* < 0.001). The number of follow-up visits had a negative association with travel distance and socioeconomic status (*P* < 0.001); the positive association was seen with DR severity (*P* = 0.002) and total cost (*P* < 0.001) on regression analysis. There was a nearly 3-fold difference in the average medical cost per eye for subjects with severe visual loss (<3/60) (INR 26,270) compared to those with good vision (≥6/12) (INR 8,510). **Conclusion:** Treatment of DR benefits, but the cost of care increases with disease severity and visual impairment. Compliance to care was related to DR severity and treatment cost. Some of the barriers could be reduced with greater advocacy and reduced travel distance.

**Key words:** Diabetic retinopathy care, economic burden, India

Diabetes Mellitus (DM) is a systemic disease. It is often accompanied by various systemic co-morbidities related to the increased glucose concentrations that degrade the endothelial lining of blood vessels of several organs.[1] People with DM (Diabetes mellitus) and DR (Diabetic retinopathy) need lifelong treatment. The economic burden of diabetes is related to the direct cost of medical care and expended GDP (Gross Domestic Product), and loss of productivity. Labor force dropout, absenteeism, and reduced productivity in the workplace contribute to the indirect economic burden. A Thailand study has shown that the cost of care in pre-dialysis chronic kidney disease (CKD) is significantly higher in patients with DM, uncontrolled fasting blood sugar, and dyslipidemia.[2] In India, where government and social health funding are insufficient,[3] more than three-fourths of the health care budget are out of pocket spending (OOPS).[4] Indian studies have shown higher healthcare costs in people with DM and complications than without complications (INR 22,274 versus INR 6,808).[5] In India, there are no studies similar to ones reported from Europe and the USA.[6-9]

The current study was designed to determine the cost of DR care at a tertiary care eye care facility in South India and its implications on the completeness of care. The tertiary center had the facility to provide care to both paying and nonpaying patients. This allowed us to analyze the health care seeking behavior of people from different socio-economic backgrounds and its impact on DR care. We also evaluated the various factors that would influence the health care delivery, in turn affecting the cost of treatment.

## Methods

This was a retrospective, observational study performed in a tertiary eye care facility. The study period was from January to June 2019. One thousand patients were randomly selected by consecutive sampling from the electronic medical records (EMR) of the Institute. Institutional review board and Ethics approval (Ethics Ref No LEC 07-19-287) was obtained. Diabetic retinopathy and diabetic macular edema (DME) were classified as per the guidelines of the International Clinical Diabetic Retinopathy (ICDR) classification severity scale.[10] High-risk PDR was defined by the extent of new vessels and the presence of pre-retinal/vitreous hemorrhage.[11] The grading of DR already existed in the EMR; it was re-verified from the available fundus photos, and optical coherence tomography (OCT) scans. Only patients with gradable

Massachusetts Institute of Technology, Cambridge, MA, USA, [1]Smt. Kanuri Santhamma Centre for Vitreo-Retinal Diseases, L V Prasad Eye Institute, Hyderabad, Telangana, India

Correspondence to: Dr. Padmaja K Rani, Smt. Kanuri Santhamma Centre for Vitreo-Retinal Diseases, L V Prasad Eye Institute, Banjara Hills, Hyderabad - 500 034, Telangana, India. E-mail: rpk@lvpei.org

images were included in the study. There were approximately 250 patients in each category of DR- mild non-proliferative diabetic retinopathy (NPDR), moderate NPDR, severe NPDR, and proliferative diabetic retinopathy (PDR) with/without high- risk characteristics (HRC). Sight threatening DR (STDR) was defined as the presence of severe NPDR/PDR with/without HRC and/or presence of moderate/severe DME.

Visual Impairment and blindness were defined as per WHO criteria as good (visual acuity ≥ 6/12), mild visual loss (<6/12), moderate visual loss (<6/18), severe visual loss (<6/60), and blind (<3/60).[12]

The patients were registered into 'non-paying,' and 'paying' categories based on their socioeconomic status. The registration system of the institute follows a proper background check of patients through a questionnaire before registering them in the nonpaying category. The non-paying patients are treated free both in the outpatient, including the diagnostic tests, and in-patient, including surgery.

Both medical and non-medical direct costs were gathered from patient charts through EMR. The medical costs included the cost of consultation, investigations, and medical interventions- lasers, intravitreal injections, and surgery. Prescription fees were estimated and assumed to have been filled. Follow up was evaluated both in the number of hospital visits and duration.

The direct medical cost included the consultation, investigations, intravitreal injections, and vitreoretinal surgeries. The indirect costs included transportation and boarding- lodging costs (estimates from a nearby hotel) [Supplementary Table 1]. The assumptions made with regards to the non- medical costs were individualized (number of follow-up visits and number of days in these visits). The values were subjective but grossly adhered to the pricing mentioned in the Supplementary Table 1. In the final analysis, we also accounted for gender and the treatment outcome.

### Statistical analysis
Demographic data were described both in absolute numbers and percentages. Other absolute values were expressed in means and standard deviations. Multivariate linear regression analysis was used to assess any associations between the number of hospital visits and distance, initial best-corrected visual acuity (BCVA), socio-economic status, the total cost of treatment, duration of diabetes, and DR severity. A paired t-test was used to note any significant difference between the BCVA at the initial and final visits. Statistical significance was defined as $P < 0.05$.

## Results

### Patient demographics
The study evaluated 1000 consecutive patients (2000 eyes) with DR in at least one eye. The study included 250 patients in the mild and moderate NPDR group, 239 patients in severe NPDR, and 261 patients in the PDR group [Table 1]. The mean duration of follow-up was 7 ± 14.4 months. There were 32.1% ($n = 321$) females in the study. This ratio was reflected in the various stages of DR as well. In this cohort, 14.6% ($n = 146$) people were treated at no cost to them. DME was detected in 27.4% ($n = 274$) people and 53.4% ($n = 538$) people had associated hypertension.

### Cost analysis
The total cost of treatment provided to 1000 people with DM was INR 23,767,838 (USD 321,187) over 6 months period. The median cost per patient was INR 8,214 (IQR 2,812-29,748)/USD 111 (IQR 38-402). The cost analysis was done for sight-threatening DR (STDR) and non-STDR, gender, and socioeconomic status [Table 2]. The standard deviations for all measures were fairly large compared to the mean values. This skew likely resulted from the great proportion of patients who did not return for follow up examination (43% of patients made only one visit).

The average number of procedures was higher in people with STDR except for surgery. The cost of care in people with STDR was two-times of people with non-STDR (INR 31,820; USD 430 versus INR 14,356; USD 194; $P < 0.001$). This had a bearing on the non-medical expenses. The cost of care of the 'paying' category was INR 22,800 (304 USD); 14.6% ($n = 146$) people received care at no cost to them [Table 2]. Fig. 1 shows the distribution of treatment costs as per DR severity and socioeconomic status of study subjects.

### Treatment distribution and cost
The numbers of investigations were similar in people with STDR and non- STDR (72% and 85% respectively). The numbers of retinal lasers and intravitreal anti-vascular endothelial growth factor (anti-VEGF) injections were higher in people with STDR (15% and 8%, respectively) than in people with non-STDR (4% and 1% respectively; $P < 0.001$).

A total of 211 patients received intravitreal injections with 191 received bevacizumab injections. 10 patients received Ranibizumab and the remaining 10 received intravitreal triamcinolone injections. The total cost of the intravitreal injections was INR 35,94000. The number of intraocular surgeries was similar in both categories of people though, it was more often vitreoretinal surgery in people with STDR (43%) and more often cataract surgery in people with non-STDR (81%).

### Regression analysis
Multivariate linear regression analysis was done to evaluate the role of various factors with a number of hospital visits [Table 3]. The number of follow up visits had a negative association with travel distance ($P < 0.001$) and the socioeconomic status of the patients ($P < 0.001$); s a positive association was seen with DR severity ($P = 0.002$) and total cost ($P < 0.001$).

The mean values of logMAR vision before and after treatment were 0.518 ± 0.678 and 0.478 ± 0.657, respectively (20/60 Snellen equivalent for both). A total of 427 (42.7%) subjects had completed one visit. A total of 573 patients (57.3%; 1137 eyes) completed treatment advice and completed at-least two follow-up visits. Among these 573 (1137 eyes) subjects, there was a statistically significant reduction in visual impairment (from 427 to 355 eyes) and blindness (from 132 to 101 eyes) after treatment ($P < 0.001$). Among 1050 eyes with DR, the retinopathy was stable in 32% ($n = 333$), improved in 35% ($n = 365$), and worsened in 34% ($n = 352$) eyes at the last follow-up.

### Cost benefit analysis of treatment
The average medical cost per eye was the least when the patients were treated early with good vision, and highest when the patients were blind due to advanced disease [Fig. 2a]. There was a threefold difference in the average medical cost per eye for blind patients (INR 26,270/355 USD) compared to those treated

**Table 1: Baseline characteristics of study subjects**

| Stage of DR | Mild (n=250) | | Moderate (n=250) | | Severe (n=239) | | PDR (n=261) | | Total (n=1000) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Gender | | | | | | | | | | |
| Male | 160 | 64 | 168 | 67.2 | 169 | 70.7 | 182 | 69.7 | 679 | 67.9 |
| Female | 90 | 36 | 82 | 32.8 | 70 | 29.3 | 79 | 30.3 | 321 | 32.1 |
| Socioeconomic status | | | | | | | | | | |
| Non-Paying | 36 | 14.4 | 34 | 13.6 | 32 | 13.4 | 44 | 16.9 | 146 | 14.6 |
| Paying | 214 | 85.6 | 216 | 86.4 | 207 | 86.6 | 217 | 83.1 | 854 | 85.4 |
| Distance (KM) | | | | | | | | | | |
| <200 | 165 | 66 | 131 | 52.4 | 117 | 48.5 | 138 | 52.9 | 551 | 55.1 |
| 200-500 | 34 | 13.6 | 46 | 18.4 | 53 | 22 | 46 | 17.6 | 179 | 17.9 |
| 500-800 | 10 | 4 | 18 | 7.2 | 10 | 4.2 | 18 | 6.9 | 56 | 5.6 |
| 800-1300 | 1 | 0.4 | 8 | 3.2 | 10 | 4.2 | 12 | 4.6 | 31 | 3.1 |
| 1300-2000 | 29 | 11.6 | 34 | 13.6 | 36 | 14.9 | 30 | 11.5 | 129 | 12.9 |
| 2000+ | 11 | 4.4 | 13 | 5.2 | 15 | 6.2 | 17 | 6.5 | 56 | 5.6 |
| DME Prevalence | | | | | | | | | | |
| DME | 21 | 8.4 | 81 | 32.4 | 117 | 49 | 55 | 21.1 | 274 | 27.4 |
| No DME | 229 | 91.6 | 169 | 67.6 | 122 | 51 | 206 | 78.9 | 726 | 72.6 |
| Duration of DM (Years) | | | | | | | | | | |
| 0-9 | 88 | 35.2 | 65 | 26 | 75 | 31.5 | 54 | 20.7 | 282 | 28.2 |
| 10-19. | 100 | 40 | 116 | 46.4 | 108 | 44.8 | 132 | 50.6 | 456 | 45.6 |
| 20+ | 56 | 22.4 | 63 | 25.2 | 52 | 22 | 75 | 28.7 | 246 | 24.6 |
| Unknown | 6 | 2.4 | 6 | 2.4 | 4 | 1.7 | 0 | 0 | 16 | 1.6 |

**Table 2: Analysis of factors influencing cost of DR care**

| | Mean Follow-up Visits | Investigations | Lasers | Injections | Surgeries | CostINR (USD) |
|---|---|---|---|---|---|---|
| Visual status | | | | | | |
| Sight Threatening | 3.84±4.16 | 2.2±2.06 | 0.45±0.81 | 0.24±0.62 | 0.15±0.48 | 29,156±42,772 (394±578) |
| Non-Sight Threatening | 2.8±2.94 | 1.1±1.53 | 0.05±0.27 | 0.02±0.16 | 0.13±0.37 | 13,172±25,752 (178±348) |
| Gender | | | | | | |
| Male | 3.43±3.75 | 1.73±1.93 | 0.28±0.68 | 0.14±0.49 | 0.14±0.41 | 22,718±39,072 (307±528) |
| Female | 3.35±3.72 | 1.77±1.94 | 0.28±0.67 | 0.15±0.51 | 0.15±0.51 | 22,274±34,040 (301±460) |
| Socioeconomic status | | | | | | |
| Non-Paying | 5.08±4.97 | 2.34±2.28 | 0.4±0.76 | 0.29±0.8 | 0.28±0.71 | 0 |
| Paying | 3.12±3.41 | 1.67±1.89 | 0.27±0.68 | 0.12±0.42 | 0.12±0.36 | 22,496±38,702 (304±523) |

Values expressed in Mean±Standard deviation

with good vision (INR 8,510/115 USD). There was an incremental trend in the cost of care from lower to higher disease state. This increase in the cost of care was 90.14% when the disease progressed from good to mild vision loss (from INR 8,510/USD 115 to INR 16,206/USD 219); the incremental cost decreased to 6.96% when the disease progressed from mild to moderate vision loss and increased thereafter [Fig. 2b]. The higher cost of care in people with mild vision loss was due to more cataract surgery done in these groups compared to people with good vision 18% and 7% respectively. Despite these variations makes

a perfect economic sense to maintain good vision in people with DM, because there is proportionally higher productivity loss associated with poor vision.[13]

## Discussion

Currently, most of the studies pertaining to the economic burden of DR have been reported from the Western world.[6-9] Despite the high prevalence of DM and DR, similar data is not published in India. The uniqueness of this study lies in the fact that it evaluated people with two different economic status
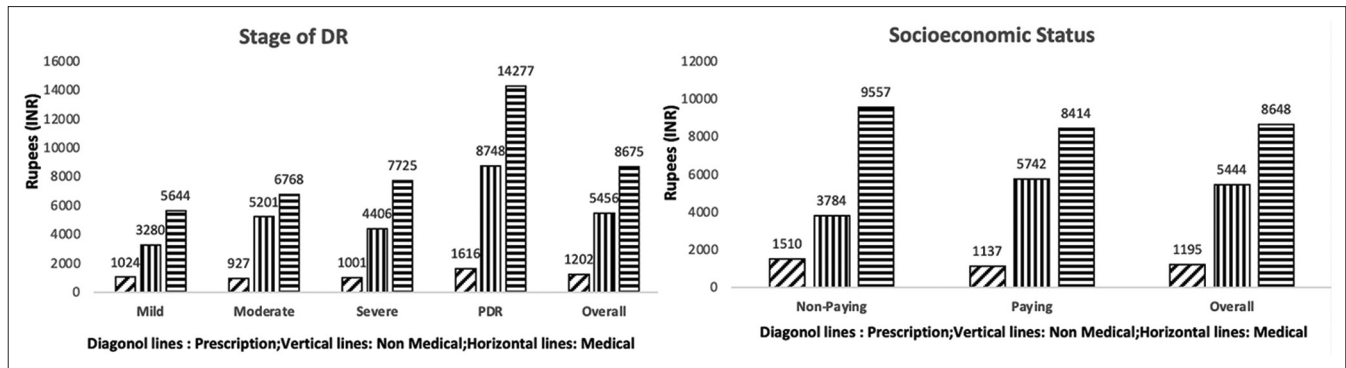
**Figure 1:** Distribution of treatment costs based on DR severity and Socioeconomic status
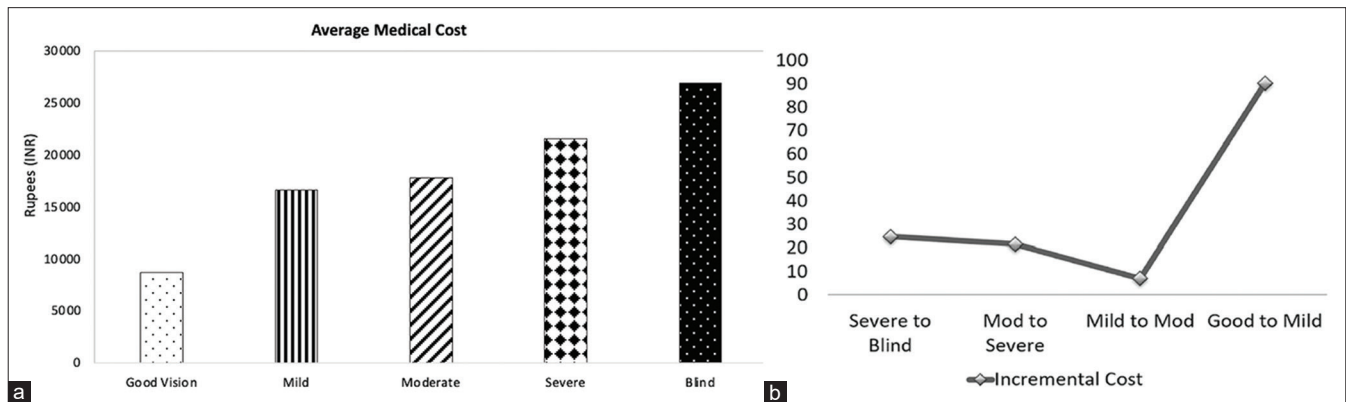


**Figure 2:** (a) Average Medical cost per eye. (b) Correlation of Incremental Medical cost with severity of visual impairment

**Table 3: Regression analysis of factors influencing follow-up care for treatment of DR**

| | Univariate | 95% CI of B | | P | Multivariate | 95% CI of B | | P |
|---|---|---|---|---|---|---|---|---|
| | B | Lower | Upper | | B | Lower | Upper | |
| Socio-economic status | -0.18 | -0.56 | 0.2 | 0.35 | -0.52 | -0.81 | -0.23 | <0.001 |
| Duration | -0.01 | -0.04 | 0.23 | 0.67 | -0.003 | -0.03 | 0.19 | 0.79 |
| Distance | -0.38 | -0.52 | -0.24 | <0.001 | -0.57 | -0.68 | -0.46 | <0.001 |
| DR severity | 0.59 | 0.41 | 0.77 | <0.001 | 0.23 | 0.09 | 0.38 | 0.002 |
| Initial BCVA | 0.71 | 0.42 | 0.99 | <0.001 | 0.16 | -0.05 | 0.41 | 0.17 |
| Total cost | 5.93E-05 | <0.001 | <0.001 | <0.001 | 6.30E-05 | <0.01 | <0.01 | <0.001 |

Dependent Variable: number of hospital visits

that nearly simulates the Indian economic strata of people in the country- people treated at no-cost to them (simulating economically underprivileged), and people treated at normal cost (simulating the middle and upper class). The combination of a providers' perspective through direct costs and a societal perspective through analysis of the effect of gender and socioeconomic status in health care provided more accurate insights on the actual costs of treating DR.

The direct medical costs associated with treatment increased across the stages of the disease, with a higher proportionate, increase between severe NPDR and PDR. This is consistent with the reports from another Asian country, Singapore; they observed a much higher treatment cost, 10 times (USD 2643 in patients with PDR than our study (USD 200).[14] Singapore study does not measure the entire cost to the society (care provider and receiver). In fact, increase in direct medical cost could only be incremental (in this study 52% to 59%), but the indirect medical cost (travel, boarding, lodging, etc.) could substantially increase because of an increased number of visits to the hospital.

We also noted that the people with STDR needed vitreoretinal surgery more often, and the people without STDR needed cataract surgery more often; the vitreoretinal surgery is more expensive than cataract surgery. We noted that people with more severe disease (such as STDR) were more compliant to treatment. Only 1/3rd of patients were females. The lower number of female patients possibly explains the societal discrimination.[3]

The system of payment was unique to the Institute, with service delivery to both paying and nonpaying patients. In the absence of robust medical insurance and third-party payment system in the country, the Institute model nearly represented the out-of-pocket spending (OOPS) for the treatment of people with DR in India.

Both medical and prescription cost was higher than average in the non-paying patients (people treated at no cost to them), and this could be related to late detection and advanced stage of DR.

The study showed that the chances for visual impairment or blindness were significantly reduced in people compliant to the treatment advice and completed follow-up care. The DR was stable or improved in 67% of eyes in people who completed treatment. An analysis of average medical treatment costs per eye showed a near 3-fold difference between the costs for treating a blind/severely visually impaired patient compared to the treatment for those with good vision. This underlies the medical and cost-benefit of early intervention when the patient's vision is still good. Treating eyes with poorer vision inflicts a higher opportunity cost and lesser medical benefit.

The economic burden of DM is estimated at USD 760 billion in the year 2019 and is likely to increase to USD 845 billion in the year 2045.[15] Three-quarters of these expenses were made in NAC (North America and the Caribbean), WP (West Pacific), and European region compared to other regions that are home to 41.8% of people with DM. When 1 in 6 people with DM in the world lives in India[15] and with the knowledge that nearly a third of them is likely to develop DR (and possible risk of vision loss) of over a period of time,[16] India needs a policy change for greater expenditure for the care of people with DM so that its many debilitating complications (and the subsequent impact on productivity) are reduced.

### Limitations and strengths

The limitations of the study were: (1) This retrospective study was performed at a tertiary eye care facility with a different demographic patient profile compared to the general population. (2) We presumed that the prescription medicines were purchased and used without actually ascertaining from the patients. (3) About 43% of people did not return for review examination, and hence we do not know the final cost of care. (4) The cost of the accompanying person in the wage, productivity, and leisure time loss was not accounted for in the analysis; so also, the patient perspective in terms of loss to follow up and the financial burden was not taken into account.

The strengths of the study were: (1) All necessary ophthalmic investigations, biochemical tests, and examination by an internist were done under one roof. (2) Cross consultation between the retina and other necessary services was possible on the same or the following day. (3) The fee structure of the Institute simulated the economic and social strata of people in India. (4) The study estimated the provider perspective of treatment care of diabetic retinopathy as accurately as possible.

## Conclusion

In conclusion, morbidity related to diabetic retinopathy is one of the most neglected yet significant aspects of this problem and thus demands prompt reforms in public health programs. The cost of care for people with DR depends on the stage of the disease. Increased costs were associated with sight-threatening DR, which often resulted from an increase in the number of intravitreal injections, retinal lasers, hospital visits, and assumed prescriptions. The trend of increased costs with the progression of disease severity indicates the need of funds for improved screening and other preventative measures; this is likely to decrease both medical and non-medical costs. The stark contrast in gender demographics amongst evaluated patients indicates the necessity for greater advocacy and addressing the gender barriers. Despite the limitations of the study, the current study provides a glimpse of the economic impact of DR and the need for a robust insurance system and government policies to reduce the cost of eye care in people with diabetes. Delivering care closer to the residence would possibly increase follow-up examination, and thus ensure completeness of care.

### Conflicts of interest

There are no conflicts of interest.

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## Supplementary Table 1: Indirect costs-Travel

| Distance from Hyderabad (km) | Bus/Train Price (INR) | Flight Price (INR) | Room/Board (per day) (INR) |
|---|---|---|---|
| Within Hyderabad | 74 | N/A | N/A |
| <= 200 | 518 | N/A | N/A |
| 200-500 | 1095 | 6731 | CBC |
| 500-800 | 1465 | 4958 | 1406 |
| 800-1300 | 2738 | 5402 | 1406 |
| 1300-2000 | 3108 (NAA*) | 5846 | 1406 |
| 2000+ (Special cases) | 3922 (NAA*) | 9768/CBC** | 1406 |

*NAA=Not Always Applicable **CBC=Case by case