SAIS Practicum 2017-2018

LV Prasad Eye Institute

Assessing Costs and Benefits of Eye Care in Rural Telangana

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I. Introduction

LVPEI's rural-eye health programs reach underserved populations in India that would otherwise not have accessible eye care. Previous LVPEI studies demonstrate that Vision Centres (VCs) eliminate the main barriers that would prevent rural patients from seeking treatment: affordability and accessibility. In addition to accessibility, patient satisfaction is a key driver in the decision to seek treatment. An analysis of patient satisfaction related to services provided at VCs show that on the whole, patients are satisfied with the care they receive. To further demonstrate the significance of VCs on the populations they serve, an investigation into the the positive externalities associated with eye care, which are not often reported when measuring patient outcomes, can be valuable.

This study aims to identify and assess the social returns of investing in VCs through an analysis of quality of life improvements and their associated costs. As a result, social impact in addition to the traditional measure, operating costs, can be taken into account when considering the economic sustainability of VCs. Specifically, this project aims to:

1. Identify how selected VCs' operating costs translate to perceived improvements in quality of life in the patients served.
2. Identify and compare the cost-effectiveness of correcting for refractive error among VCs and other service providers.
3. Identify and compare the cost-effectiveness of cataract surgery conducted at Adilabad Secondary Centre to other service providers.

Three VCs were selected for this analysis in Telangana state: Jainath, Jannaram and Utnoor. These range from low-performing, average-performing, and high performing respectively, measured by number of patients seen per day.[1] The cost-effectiveness analysis focuses on two relevant treatments: refractive error correction through spectacles and cataract surgery. A total of 4,131 patients were seen at Jainath, Jannaram and Utnoor between April and September 2017, of whom 43% were diagnosed with refractive error and treated with spectacles, and 6% with cataract or a similar condition. Overall, cataract surgery is the most frequently performed procedure within the LVPEI network, accounting for 34% of all surgical procedures from 2016-2017.[2]

To achieve these objectives, two measures commonly used in the field of health economics were employed: a cost-consequence analysis (CCA) and a cost-efectiveness analysis (CEA), which is a form of cost-effectiveness analysis. While a cost-benefit analysis is another popular tool in health economics, its benefits are expressed in monetary terms, which is not ideal for this study. Since rural eye-health programs focus on economically disadvantaged patient populations, expressing patient benefits in terms of Indian rupees (₹) saved as a result of treatment could potentially underestimate the impact of LVPEI services. Both the CCA and CEA express the benefits of treatment in terms of

[1] Performance indicators provided by LVPEI

[2] LVPEI 2016-2017 annual report: 34% of patients received cataract surgery. Second largest treatment was Retina and Vitreous at 29%. LV Prasad Eye Institute. (2017). *Activity Report 2016-2017*. Hyderabad.

patient-reported perceived change in quality of life. The CCA is utilized to achieve objective one in the list above, and the CEA is utilized to achieve objectives two and three. The results of this study provide economic indicators of individual patient impact, expressed as the cost to attain an improvement in quality of life.

The remainder of the document is structured as follows: section 2 provides a brief overview of the patient population at the selected VCs using patient records from LVPEI to contextualize the analysis. Section 3 presents the Cost Consequence Analysis, its inputs and results. Section 4 does the same for the Cost Effectiveness analysis. Section 5 concludes the study and provides insights for further research.

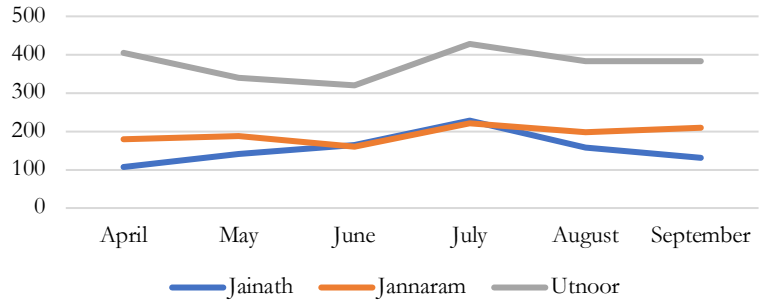
II. Context: Vision Centres

In 2017, LVPEI implemented a robust digital data record of all the patients seen at VCs across the system. The SAIS Practicum team had access to a total of 4,131 records of patients screened at the three VCs included in the study, Jainath, Jannaram and Utnoor, between April and September of 2017.[3] The following section briefly describes the characteristics of LVPEI's beneficiaries, in order to contextualize the reader with overall trends and key differences between the Centres.

2.1. Patient Volume

There are notable differences in the volume of patients screened in the three towns. Utnoor served the highest patient volume of all – roughly half of the total – while Jannaram and Jainath served 27% and 21% of all patients, respectively. On average, Utnoor served 12.3 patients per day, Jannaram 6.3, and Jainath 5.1. Since a significant portion of the costs in each VC is fixed, these disparities have important implications when calculating the cost per patient for the Cost Consequence Analysis, as explained in Section 2.

Figure 1. Number of Patients per Month per VC



Source: LVPEI Patient Data, 2017 – Authors' calculations

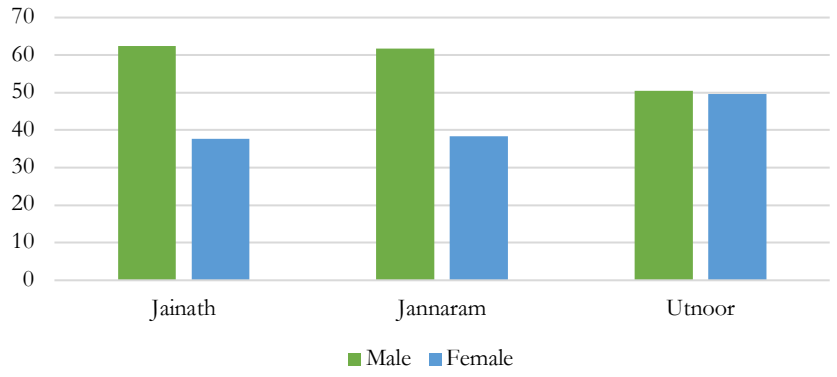
[3] The vast majority of patients (95%) went to the Vision Centres once during this period, yet there are repeated records for roughly 5% of the patients, which leads to a total of 4,341 records.

The differences in the number of patients seen at each Vision Centre can be partly attributed to the characteristics of the towns. Utnoor is the most densely populated town of the three and would be considered a large village by Kovai et al.[4] According to the 2011 Census of India, roughly 25% of Utnoor's 63,000 inhabitants live in its urban area, whereas the other two towns are considered to be 100% rural and would be classified as small villages.[5] The uneven distribution of patients between the VCs can therefore possibly be explained by the proportion of urban inhabitants given the differences in costs of transportation in rural areas compared to urban areas.[6]

2.2. Gender and Age of Patients

In addition to the volume of patients, Utnoor differentiates itself as the only VC with a relatively even distribution of male and female patients. In contrast, slightly over 60% of the patients served at Jainath and Jannaram were male. It is worth noting that a meaningful proportion of the female population in India still lacks access to health services and thus LVPEI's reach through the Vision Centres is certainly an accomplishment.

Figure 2. Gender distribution by Vision Center, %



Source: LVPEI Patient Data, 2017 – Authors' calculations

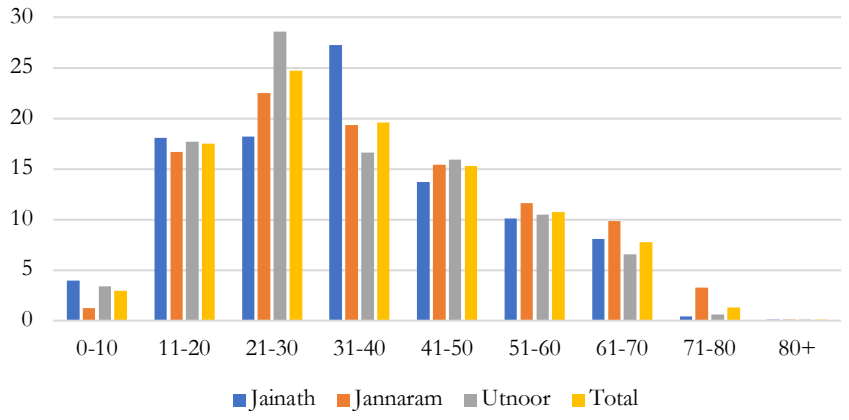
Interestingly, many of LVPEI's beneficiaries in these Centres are young adults, which suggests important achievements in delivering preemptive eyecare to the communities it serves. Indeed, roughly 45% of the patients are 30 years of age or below, and many of them have good eyesight at the time of screening. However, an average age of 36 years (median 33) suggests that further efforts could be made to reach children and youth and thus enhance their quality of life from earlier on, given the proven impact of improved vision on school performance. No significant differences in age arise across VCs.

[4] Kovai, V., et al (2010). Comparison of patient satisfaction with services of Vision Centres in rural areas of Anhra Pradesh, India. *Indian Journal of Ophthalmology*. 58: 407-413.

[5] According to the Census, Jainath and Jannaram, are home to 48,000 and 53,000 people, respectively, yet distributed sparsely across a large territory.

[6] Less than 5% of the patients report coming from another village.

Figure 3. Distribution of patients by age, %

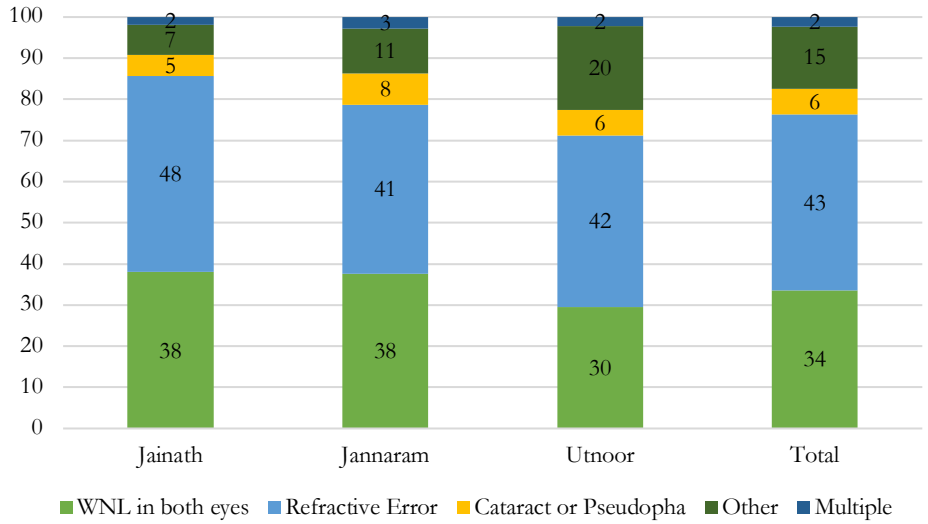


Source: LVPEI Patient Data, 2017 – Authors' calculations

2.3. Diagnosis and Take-Up

The patient data collected by LVPEI also provides important information regarding the type of diagnosis patients receive when visiting the VC. A majority of the diagnoses are refractive error, while cataracts and other types of issues account for approximately 24%. Roughly a third of the patients are found to have good vision (Within Normal Limits – WNL), which again attests to the important role of LVPEI in fostering a culture of preventive care in the communities it serves. While similar, it is worth highlighting that the proportion of patients with other diagnoses is almost 10% higher in Utnoor compared to the other two VCs.

Figure 4. Diagnosis, Total and by Vision Centre, %



Source: LVPEI Patient Data, 2017 – Authors' calculations

After receiving a diagnosis of refractive error, most patients decided to follow LVEPI's advice. 18% of patients were prescribed to keep their same spectacles and 72% were diagnosed with a new prescription. The remaining 25% of patients did not buy new spectacles after receiving a new prescription; a behavior that may be driven by income, or by indifference to small changes in the prescription. Overall, the three Vision Centres seem to be quite effective in incentivizing the appropriate action by patients, when prescribed with refractive error.[7]

Figure 5. Take-Up of Spectacles by Vision Centre

Diagnosis		Jainath	Jannaram	Utnoor	Total
Continue same spectacles		50	111	207	368
		11%	22%	20%	18%
Prescribed new spectacles	Bought	248	300	586	1,134
		55%	58%	57%	57%
	Didn't buy	153	104	238	495
		34%	20%	23%	25%
Total		451	515	1,031	1,997
		100%	100%	100%	100%

Source: LVPEI Patient Data, 2017 – Authors' calculations

The patient data also provides some information on the number of people that were seen at the Secondary Centre after receiving a referral for cataract or other issue. Less than one third of referred patients (28% or 151) presented themselves to the Secondary Centre after the referral. Overall, this pattern might be a result of limited financial capabilities on the side of the population served, the time required to travel and receive the procedure, or other factors associated with the context. However, it is interesting to note that Jannaram had the highest compliance rate, of about 42%, and is also the farthest VC from Adilabad.

III. Cost-Consequence Analysis: Impact Across Centres

After careful consideration of the objectives of the project and the resources available for field work, the SAIS Practicum Team decided to implement a Cost-Consequence Analysis (CCA). CCAs essentially express the costs and benefits of an intervention in the form of a balance sheet.[8] Namely, the methodology allows for the analysis of the cost of generating a given outcome. Contrary to most other methodologies, CCAs are easily interpretable by different stakeholders and allow for a multidimensional approach to impact.

[7] It is also worth noting that the actual usage of spectacles cannot be extrapolated from this numbers.

[8] Gage, Heather, et al. (2006). Evaluating rehabilitation using cost-consequences analysis: an example in Parkinson's disease. *Clinical Rehabilitation*. 20: 232-238.

The CCA presented below assesses how much it costs LVPEI to generate a perceived change in patient quality of life in the three VCs. To do so, the SAIS Practicum Team estimated a ratio of cost per patient divided by perceived change in terms of a dichotomous variable (change or no change). The cost per patient was calculated using administrative data from LVPEI. The perceived impact was assessed through a survey implemented in Jainath, Jannaram, and Utnoor in January of 2018 by the Team with the support of LVPEI. The questionnaire contained open-ended questions regarding five dimensions of quality of life, the answers to which were later re-coded. One of the most important contributions of this project is the simple interpretation of the results.

A notable aspect of the cost analysis performed here is the use of two different measures of costs. On one side, the average financial cost of serving each patient is estimated in line with other literature concerned with providing treatment as the recurring costs of operating the VCs. Yet, given that some VC operating costs are recovered through the retailing of spectacles, another ratio is estimated using the unrecovered costs (or surplus) generated by each of the VCs. Jointly, the two analyses allow for a comprehensive picture of the cost of generating an impact in patients of LVPEI.

The following subsections describe the estimations on cost per patient and the assessment of perceived impact across the centres. The last subsection presents the results of the CCA and discusses them in light of the objectives of the study.

3.1. Cost Analysis

In order to perform the Cost-Consequence Analysis, an approximate cost per patient incurred by LVPEI is needed. This is determined by combining the recurring operating costs of the three VCs with the patient data presented in section 2.1.

3.1.1. Vision Centre Recurring Costs and Income

LVPEI provided cost and income records by VC for the months of April through September, 2017. These accounts were classified into seven categories:

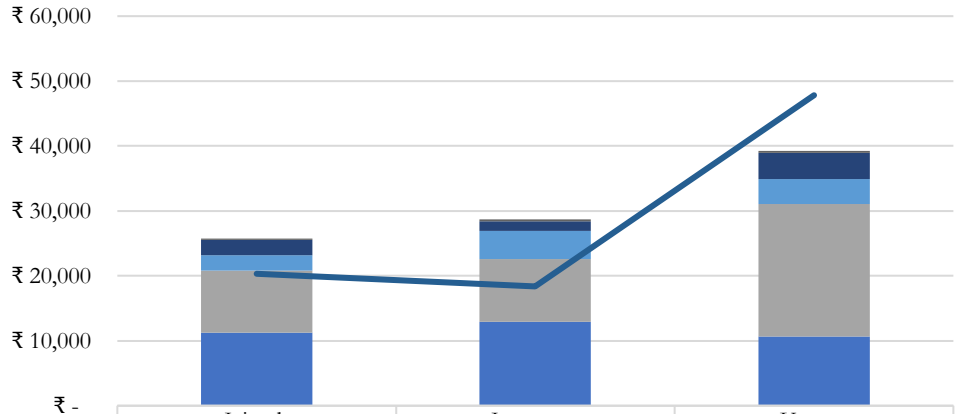
1. **Salary** of the technician posted in the Vision Centre;
2. **Material Consumption**, comprised of supplies, medication (e.g. eye drops) and frames and lenses to sell to patients with a refraction diagnosis;
3. **Rent;**
4. **Office Maintenance**, which includes utility services (e.g. water, telephone, etc.), office supplies and similar expenses;
5. **Travel Expenses;**
6. **Repairs and Maintenance**, which includes irregular expenses such as furniture, painting works and electrical repairs;[9] and

[9] The analysis presented here excludes Repairs and Maintenance. By definition, LVPEI incurs in these costs only sporadically and thus assessing a correct average monthly average given the information available would prove inaccurate. This analysis also excludes capital costs given that they are not incurred by LVPEI on a rolling basis although they are included in financial statements.

7. **Income** from selling spectacles.

The aggregated cost analysis provides two important elements for the CCA. Firstly, most costs are fixed and independent of the volume of patients. As Figure 6 suggests, recurring costs vary across VCs due to differences in Material Consumption. When excluding this category, recurring costs across VCs vary by less than ₹ 3,000 per month. This suggests that fixed costs are mostly optimized and thus the variations in the cost of generating a change will depend on variable costs. Since Material Consumption costs are driven by patient volume, it is unsurprising that Utnoor has higher monthly costs given its higher population and density.

Figure 6. Monthly Recurring Costs and Average Income by Vision Centre



	Jainath	Jannaram	Utnoor
Travel	₹ 204	₹ 341	₹ 342
Office Maintenance	₹ 2,344	₹ 1,430	₹ 3,990
Rent	₹ 2,420	₹ 4,307	₹ 3,833
Material Consumption	₹ 9,541	₹ 9,662	₹ 20,427
Salaries	₹ 11,247	₹ 12,961	₹ 10,683
Income	₹ 20,322	₹ 18,375	₹ 47,820

Source: LVPEI Cost Data, 2017 – Authors' calculations

It is also worth noting that a majority of the recurring costs of the three VCs are recovered through the retail of spectacles. Jainath's cost recovery ratio was 79% for that period, while Jannaram's was 64%.[10] Further, Utnoor's revenue stream allowed for full cost recovery and generated a surplus with a cost recovery ratio of 122%. Specifically, the unrecovered recurring costs were ₹ 5,434 per month in Jainath and ₹ 10,325 in Jannaram. Utnoor's surplus amounted to ₹ 8,543 per month. Altogether, this means that the *true recurring* cost to LVEPI of operating the three VCs amounts to just over ₹ 7,200 –a very different figure to the ₹ 93,700 per month if income is not taken into account in a typical CCA.

[10] Cost recovery ratio is defined as Total income of the VC/Recurring expenses of the VC, in line with Kovai et al. (2010).

Given LVPEI's mission to target underserved populations across the country, partial cost recovery in certain VCs should be expected. In fact, the high recovery rates of these centres should be highlighted as a strength of LVPEI's system. As the case of these VCs suggests, operating in large villages (e.g. Utnoor) translates into higher financial viability at a system level. Incorporating the unrecovered costs into the CCA in addition to the total financial costs might thus be of practical relevance for LVPEI's management.

3.1.2. Costs per Patient

In order to arrive at a cost per patient, the average of recurrent costs per month are divided by the average number of patients served each month. On average, a patient costs ₹ 129 per month, if income is not taken into account. As expected, Utnoor's price per patient is lower than that of the other two VCs, due to its patient volume. If only unrecovered costs are taken into account, however, the figures are much lower. Each patient costs to the system roughly ₹ 10 across these VCs, as a result of Utnoor's outstanding performance. For example, the LVPEI system subsidizes just ₹ 35 per patient of recurring costs in Jainath, given the Centre's ability to recover roughly 80% of its costs.

Figure 7. Financial and Unrecovered Cost per Patient

Monthly Averages	Overall	Jainath	Jannaram	Utnoor
Patients	724	155	193	376
Financial recurring costs	₹ 93,732	₹ 25,756	₹ 28,700	₹ 39,275
Unrecovered recurring costs	₹ 7,215	₹ 5,434	₹ 10,325	₹ 8,543*
Financial cost per patient	₹ 129	₹ 167	₹ 149	₹ 104
Unrecovered cost per patient	₹ 10	₹ 35	₹ 54	₹ 23*

Source: LVPEI Cost & Patient Data, 2017 – Authors' calculations. Note: * denotes surplus instead of cost

There are two key points to note from this analysis:

- The ratio includes all patients served with no regard for their diagnosis or the take up of the treatment. Since the analysis presented here is concerned with the costs from the perspective of LVPEI, it is important to account for all the people that used the services and thus utilized resources from the organization. The cost of serving patients with different diagnoses (i.e. WNL, refraction, etc.), for instance, is essentially, identical from the perspective of LVPEI since the process followed by the technicians is the same. Similarly, the cost to the VC of serving someone who is referred and goes to the Secondary Center is identical to that of serving someone who does not follow the referral.
- These figures do not include all costs of operating the VCs from a systems perspective, but rather the recurring costs of operating the Centres on a daily bases. The cost data utilized here does not incorporate the expenses of training the technicians, managing them,

developing the infrastructure,[11] or capital costs. As a result, the costs should not be interpreted as the final cost of delivering LVPEI's services to a certain area. However, these costs allow for relevant comparisons between Centres, and account for a major part of the operating costs and therefore are highly relevant for LVPEI's management.

3.2. Measuring Impact: Perceived Change

As mentioned earlier, the SAIS Practicum Team considered multiple methodologies to assess the impact of Vision Centres in the communities they serve. After careful review, the Team decided to implement a questionnaire containing both open- and close-ended questions about their perceptions of how the treatment affected their quality of life. This approach allowed the team to capture impact from a multidimensional perspective, and was deemed appropriate for a small sample in which following the same patients before and after the treatment was operationally impossible. Additionally, a qualitative approach proved highly valuable given the Team's limited ability to test the questionnaire in the field in advance or adapt the questions based on a pilot. It allowed to explore interesting dimensions of impact covered in the other document presented as part of this project.

The impact modules of the survey were developed using inputs from multiple sources. Some questions were based on the Visual Function Questionnaire, a standardized tool used to measure quality of vision in patients with different pathologies. Other questions were adapted from the EQ-5D questionnaire, a standardized instrument measuring health-related quality of life, in line with the open-ended nature of the survey. Similarly, some questions of the RAND 36-Item Health Survey were adapted for this study. This rigorous approach to the design of the survey allowed the Team to capture a wide range of dimensions of impact.

All impact questions were classified into five separate dimensions, based on standardized quality of life questionnaires, which capture the multiple channels through which eye care affects patients' lives:

1. **Mental Wellness:** Understood here as perceived changes in negative emotions, such as stress and depression, as well as changes in the ability to concentrate after treatment.
2. **Daily Living:** Questions regarding restrictions or impairments generated by visual impairment in terms of work, recreation and self-care, including requiring help from others.
3. **Security:** Focuses on a feeling of security in the immediate physical surroundings, e.g. around the house and in the town.
4. **Productivity:** Involving a component of perceived change in income and of time working.
5. **Mobility:** Addresses changes in the perceived ease of getting around, for example driving or walking.

[11] Initial capital cost to develop infrastructure has been estimated at less than 15 rupee per person for population unit of 50,000. See Kovai, et al (2010).

The following subsections present some basic facts on the implementation of the survey and provide a summary of its most relevant results.

3.2.1. Questionnaire Implementation & Processing

- **Dates:** The questionnaire was implemented in the field between January 17 and 19, targeting the population of one Vision Centre at a time.
- **Sampling:** LVPEI staff contacted respondents in advance and arranged interviews based on the treatment they received and on convenience, ensuring a high response rate. Some respondents were chosen following snowball sampling. Roughly half of the respondents benefitted from spectacles and roughly half from cataract surgery.
- **Administration and Translation:** The questions were translated from English to Telugu on-site by LVPEI staff and translated the respondents' answers to English for the SAIS Team member to codify and annotate. Although a training session on the translation procedure was performed in Adilabad on January 16, it is possible that the questions were not asked exactly in the same way and that some nuances of the answers were lost in translation. The survey was approved by LVPEI's IRB prior to its implementation.
- **Possible Sources of Bias:** Respondents were often accompanied by family members or other members of the community, and therefore some of the answers might be biased. Additionally, since the survey was performed by LVPEI staff, respondents may have answered the questions with some positive bias. Nevertheless, it is important to highlight that LVPEI and the SAIS Team took all possible precautions to ensure high quality of data, including a comprehensive confidentiality agreement and a robust training.
- **Data Entry:** The SAIS Practicum Team manually performed the data entry in the days following the fieldwork. Since most of the impact questions were open-ended, the Team recoded these questions into a dichotomous variable which assessed whether the respondent had perceived a positive change before and after the treatment in that dimension. The complexity of the qualitative data was used for the narrative presented as part of this project.

3.2.2. Survey Results

Respondents were evenly distributed across VCs and treatments. The survey was administered to 56 individuals, 19 of whom were from Jainath, 21 from Jannaram, and 16 from Utnoor. 20 respondents were prescribed with cataract surgery and 29 with spectacles.[12] While the sampling methodology and sample size do not allow for statistical extrapolation to the full population,[13] the results provide lights on patterns within a notable set of patients.

[12] There was no information on the prescription of 7 of the patients on LVPEI administrative data or on whether they had received the treatment or not. 1 of these respondents was interviewed in Utnoor and 3 in each of the other towns. Due to this, these patients are not included in the final results.

[13] The sample is not representative.

The sample had a similar distribution as the overall patient population in terms of gender, but differs in terms of age and treatment. Roughly a third of the respondents were female, which is comparable to 40% overall. The average and median age of the sample was 50 years old, while that of the whole patient population was 33 and 36, respectively. The age difference may be a result of the convenience sampling strategy and a decision to target approximately half the sample from each treatment. Including a disproportionate number of cataract patients likely skewed the age distribution.

The results of the survey were quite positive. Overall, 84% of respondents reported perceiving a positive change in their quality of life in at least one dimension. As figure 8 indicates, more than three quarters of the respondents perceived better concentration or less stress. About half of the respondents reported a change in their ability to get around town. Roughly a fifth of the people interviewed perceived a change in their income or in the time they spend working. This figure, while high, might be underestimated given the respondents' ability to recall differences in their income. These results are used to estimate the cost of generating a positive change in patients' lives in the next subsection.

Figure 8. Perception of change by dimension and Vision Centre

	Overall	Jainath	Jannaram	Utnoor
Mental Wellness	77%	74%	71%	88%
Mobility	50%	53%	43%	56%
Security	46%	42%	33%	69%
Daily Living	34%	26%	24%	56%
Productivity	21%	16%	19%	31%
At least one dimension	84%	79%	81%	94%

Source: Survey Data – Authors' calculations

3.3. Cost Consequence Analysis Results and Discussion

The CCA consists of comparing the cost per patient to the perception of change in a ratio, in order to estimate the cost of generating a change in a certain dimension for LVPEI. Figure 9 presents the results of this ratio for total financial costs and for unrecovered costs. The results suggest that is costs approximately ₹ 154 for a perceived change per patient, with a notable variation between Utnoor and the other two VCs given their differences in patient flow. More specifically, it takes approximately ₹ 209 for LVPEI to generate a positive change in mental wellness in Jannaram, for instance. While these results are not statistically significant due to the sample size and the scope of the project, they do provide an interesting approximation to the financial value of affecting people's lives.

Figure 9. Cost Consequence Analysis Results

	Costs	Overall	Jainath	Jannaram	Utnoor
Mental Wellness	Financial	₹ 169	₹ 226	₹ 209	₹ 119
	Unrecovered	₹ 13	₹ 48	₹ 75	₹ 26*
Mobility	Financial	₹ 259	₹ 316	₹ 348	₹ 186
	Unrecovered	₹ 20	₹ 67	₹ 125	₹ 40*
Security	Financial	₹ 279	₹ 395	₹ 447	₹ 152
	Unrecovered	₹ 21	₹ 83	₹ 161	₹ 33*
Daily Living	Financial	₹ 382	₹ 633	₹ 626	₹ 186
	Unrecovered	₹ 29	₹ 133	₹ 225	₹ 40*
Productivity	Financial	₹ 605	₹ 1,055	₹ 783	₹ 334
	Unrecovered	₹ 47	₹ 222	₹ 282	₹ 73*
At least one dimension	Financial	₹ 154	₹ 211	₹ 184	₹ 111
	Unrecovered	₹ 12	₹ 44	₹ 66	₹ 24*

Source: LVPEI Cost & Patient Data, 2017, & Survey data – Authors' calculations. Note: * denotes surplus instead of cost

As suggested earlier, the high recovery ratios across the VCs translate into low unrecovered costs throughout the system. This, in turn, translates into very low unrecovered costs of impact at the Vision Centre level, as Figure 9 indicates. Generally, generating a positive perceived change in at least one of the dimensions of this study seems to be as low as ₹ 12 for the system. Utnoor's surplus is capable of reducing the overall unrecovered costs significantly. Even impacting the productivity dimension seems to be relatively uncostly when income is taken into account. LVPEI management and donors may well use these figures as indications of the real costs they need to incur when makin a meaningful impact.

Beyond the specific estimations of the CCA, the results presented here allow for an understanding of one of the biggest strengths of the LVPEI model. Some VCs operate in challenging contexts where patient flow is unable to cover all expenses through the retailing of spectacles. Yet a combination of high perceived impact across Centres, and high performing Centres (Utnoor, in this case) may well allow LVPEI to generate impact at very small cost to the system overall. VCs in small communities are especially relevant to LVPEI's mission, and the present analysis indicates that the true cost of running them may well be marginal in comparison to the impacts they generate.

Despite its multiple strengths it is important to highlight some of the limitations of the CCA performed in this section.

- Given the nature of the project, specifically the fact that the Team could not follow patients before and after the intervention or reach a statistically significant sample, the impact assessment is based on respondents' perception of impact after the treatment. This may have been affected by recall bias, by the presence of LVPEI staff during the interviews, by translation issues, or simply by a difficulty in isolating the effect of the treatment from other changes in the patients' life. This could be solved through a more comprehensive research project, which would require significantly more resources and time.
- Related to the previous point, a qualitative assessment of impact allowed the SAIS Practicum Team to capture many facets of LVPEI's effect on their lives. However, the lack of a scaled measurement makes comparison across individuals and dimensions hard to interpret and grasp. In this regard, using a more quantitative approach to impact, through a Likert scale, for example, could have refined the conclusions of the CCA. Yet, the characteristics of the surveyed population and the other limitations of the study suggest that this approach to measurement was also appropriate.
- In a more methodological sense, the Cost Consequence ratio may be estimated in different ways. For instance, costs could be divided between treated patients and only-screened patients, yet the benefits of preventive care led the SAIS Practicum Team to choose this option. Additionally, a separate analysis by treatment would have also be ideal, yet the number of patients by treatment per VC were too low for this type of analysis.

Overall, despite these notable limitations, the results of the CCA bring to light relevant dynamics of costs and patient perception for the three VCs, which could well be taken to other contexts in the system.

4. Cost Effectiveness Analysis: Impact Across Providers

A Cost Utility Analysis (CUA) is a form of Cost Effectiveness analysis that determines effectiveness based upon the patient's perceived value of treatment.[14] This is the ideal tool to measure cost-effectiveness on an individual basis.[15] Utility is typically measured on a scale from 0 to 1, with 0 representing death and 1 representing perfect health. In this analysis, utility is expressed as a quality-adjusted life year (QALY). There are several methods used to develop this score, all of which require patient assessment both before and after treatment. Due to the limited scope of this study, pre- and post- treatment assessment was not feasible, therefore a QALY specific to LVPEI's patients was not generated. However, the QALY is transferable across similar contexts allowing for application of previously generated QALYs for this study. Although utility scores are technically population specific, "the utility differences between two separate populations are not as sizeable as

[14] Lansingh, V. C., Carter, M., & Martens, M. (2007, September). Global Cost-effectiveness of Cataract Surgery. Opthalmology, 114(9), 1670-1678.
[15] Ibid. p. 1671.

one may expect, empirically."[16] Similar socioeconomic characteristics of the population studied allow for comparable utility values.

After an extensive literature review, two studies were identified with similar patient populations to that of LVPEI. There are only a handful of published cost-utility analyses on cataract surgery from around the world, with even fewer focused on refraction and dispensement of spectacles. The majority of refraction studies focus on the benefits to children rather than adults. Consequently, the patient population measured for refraction is more distant to LVPEI than that of cataract surgery. The result of the CUA is an incremental cost effectiveness ratio (ICER), expressed in this case as the amount of Indian rupees (₹) needed to obtain one additional QALY as a result of treatment.

4.1. Cost-Utility Analysis: Refraction & Spectacle Dispensement

4.1.1. Cost Analysis

Various cost calculations were conducted to provide several versions of the analysis to allow for more comparisons with different providers. The first calculation accounts only for costs incurred by LVPEI to provide treatment. Direct treatment costs are those that were provided by LVPEI, totaling ₹ 851 per patient. This combines supply costs at ₹ 260, labor costs at ₹ 360, and other costs at ₹ 231. This cost is constant across all VCs in this study, and involves the cost of screening and consultation by the vision tech and cost of spectacles.

Overhead costs, described as recurring operating costs of VCs including office maintenance expenses, rent, travel expenses, and repairs and maintenance were also included.[17] Salary and material consumption costs were excluded since they are accounted for in the treatment cost per patient.[18] Separate overhead cost calculations were conducted for each VC. Given that all VC patients are screened, one calculation divides the total expenses between April and September 2017 by total patients seen during the six-month period. This results in an overhead cost per patient. However, since not all patients that are screened are prescribed and purchase spectacles, a separate calculation multiplies the proportion of total patients that purchased spectacles at each VC by total expenditure, resulting in total recurring expenses for patients that purchased spectacles. This amount was then divided by number of patients, resulting in a separate overhead cost per patient that purchased spectacles.[19]

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[16] Weinstein, M., Torrance, G., McGuire, A. (2009). QALYs: The Basics. *Value in Health, 12*(1), S5-S9.

[17] Non-recurring painting and furniture costs in Utnoor and Jannaram were removed.

[18] Costs are calculated under the assumption that itemized treatment costs provided by LVPEI are per patient treated that purchases spectacles. These itemized treatment-specific costs would account for the appropriate portion of overhead expense per patient in the areas of material consumption and salary.

[19] For Total Refractive Error Costs based on Patients that Purchased Spectacles see Figure A1 in Appendix.

Figure 10. Total Refractive Error Costs based on Total Patients Screened, ₹ of 2017

	Jainath	Jannaram	Utnoor
Overhead Costs	₹ 32	₹ 40	₹ 22
Capital Costs	₹ 176	₹ 133	₹ 76
Subtotal	₹ 208	₹ 173	₹ 98
Treatment Specific Costs			
Miscellaneous Costs	₹ 231	₹ 231	₹ 231
Supply Costs	₹ 260	₹ 260	₹ 260
Labor Costs	₹ 360	₹ 360	₹ 360
Subtotal	₹ 851	₹ 851	₹ 851
Total Costs to LVPEI	₹ 1,059	₹ 1,024	₹ 949
Discounted at 3% for 5 years	₹ 914	₹ 883	₹ 819
Patient Costs			
Direct Costs	₹ 132	₹ 132	₹ 132
Indirect Costs	₹ 98	₹ 98	₹ 98
Subtotal	₹ 230	₹ 230	₹ 230
Total Costs to LVPEI & Patient	₹ 1,289	₹ 1,254	₹ 1,179
Discounted at 3% for 5 years	₹ 1,112	₹ 1,082	₹ 1,017

Source: LVPEI Cost, 2017, & Kovai, et al (2010) – Authors' calculations

Capital costs were calculated for the 6-month period by dividing the annual capital cost of each VC in half.[20] Similar to the method used for determining operating costs per patient, two calculations were produced. One reflects all patients screened at the VC and the other accounts for just those patients that purchased spectacles.

Since there is no fee for screenings at VCs, the only direct cost to patients is the purchase spectacles. An average amount of ₹ 132 per pair of spectacles was used as direct cost. Due to the limited scope of this study, indirect costs to the patient were not calculated during fieldwork in January 2018. This analysis will incorporate indirect patient costs that were estimated in a previous cost-benefit analysis of LVPEI VC patients in 2007.[21] Indirect costs include the cost of travel to the VC for both patients and companions, along with the opportunity cost of time spent away from wage-earning activities. The mean indirect cost was ₹ 46 in 2007, inflated to ₹ 98 for 2017.[22]

[20] Capital costs were calculated based on information provided by LVPEI. All assets were depreciated at 15% per year using the diminishing balance method.

[21] Op. Cit. Kovai, et al (2010)

[22] Inflated prices were calculated using the tool on StatBureau.org for India: statbureau.org, 2018.

All costs were discounted to reflect the economic premise that both "costs and benefits that are deferred have lower value than those that are realized immediately."[23] A standard rate that was used for discounting the utility measure in the reference study was applied to LVPEI costs, 3% over 5 years.

4.1.2. Utility Analysis

The QALY developed for refraction stems from a study conducted in Zambia in 2011.[24] Patients included in this study were treated at three hospitals: Lusaka Eye Hospital, Livingstone Hospital, and Choma Hospital. These facilities are urban, semi-urban and rural respectively. A total of 41 patients were included in this sample, of which 28 were treated for refractive error and 13 for presbyopia. Mean ages for refractive patients and presbyopia were 33 and 50 respectively, with a total mean age of 39. Utility values include both refraction and presbyopia patients since the sample size of solely refractive error was too small.

Utility was measured through patient self-assessment using the EQ-5D, a health-related quality of life (HRQOL) instrument. The EQ-5D measures quality of life across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. This questionnaire was administered preceding treatment and six months post treatment. A state-transition model was used to estimate the utility over time, and future health effects were discounted at 3% per year.

Baseline EQ-5D utility value (QALY) was 0.850, and at follow-up 6 months after surgery was 0.925, with an estimated gain of 0.075. After modelling this over time, the incremental utility gain is 0.192. Additional details on the methodology used and sensitivity analysis can be found in the original article.

4.1.3. Incremental Cost Effectiveness Ratio (ICER)

In all scenarios, Utnoor is most cost-effective of the three VCS, followed by Jannaram then Jainath, which is not surprising given its higher patient volume. The most commonly used threshold for determining whether the ICER is cost-effective was developed by the World Health Organization (WHO) in 2002 and the WHO-CHOICE program.[25] The WHO has deemed an intervention cost-effective if the cost per QALY gained is less than three times the country's GDP per capita. An intervention is considered highly cost-effective if the ICER is less than the annual GDP per capita.[26] As the Indian government has not established a national standard for cost-effectiveness, the WHO threshold is the most standardized indicator of cost-effectiveness. Utilizing

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[23] U.S. Department of Veterans Affairs. (2016, April). *Cost-Effectiveness Analysis.* Retrieved March 15, 2018, from Health Economics Research Center: https://www.herc.research.va.gov/include/page.asp?id=cost-effectiveness-analysis

[24] Griffiths, U. et. al. (2014). Cost-effectiveness of eye care services in Zambia. *Cost Effectiveness and Resource Allocation, 12*(6), 1-9.

[25] World Health Organization. (2002). *World Health Report 2002: Reducing Risks, Promoting Healthy Life.*

[26] Ibid.

this threshold, each VC is highly cost effective, as India's per capita GDP in 2016 was ₹1,15,074 ($1,710).[27]

Figure 11. Incremental Cost Effectiveness Ratio (ICER) for Refractive Error based on Total Patients Screened at VCs

Method		Jainath	Jannaram	Utnoor
Including Patient Cost	Discounted Cost	₹ 1,115	₹ 1,085	₹ 1,021
	Incremental Utility Gain	0.192	0.192	0.192
	ICER	₹ 5,809	₹ 5,651	₹ 5,316
	Average ICER		₹ 5,574	
Excluding Patient Cost	Discounted Cost	₹ 914	₹ 883	₹ 819
	Incremental Utility Gain	0.192	0.192	0.192
	ICER	₹ 4,758	₹ 4,600	₹ 4,265
	Average ICER		₹ 4,541	

Source: Authors' calculations

An alternative method is to compare the ICER to a benchmarked intervention in the same country, and use that as a cost-effectiveness threshold. Although a published study on cost-effectiveness of adults in India was not found, a comparison can be made to the reference study in Zambia. The ICER in Zambia was $375 (2010 USDs), equivalent to $420/QALY in 2017, including patient transport costs. Removing patient costs results in an ICER of $360 (2017 USDs). The average LVPEI ICER removing patient costs is $70 (2017 USDs), much lower than that of Zambia.[28]

4.1.4. Discussion

Several population characteristics are more likely to affect the degree of utility gain after treatment than others. When comparing LVPEI's patient population to that in Zambia, key similarities that predict similar utility levels include socioeconomic characteristics, payment for services, and access to care. A factors that may lead to differences in utility gain is the mean age of each population.

Socioeconomic Characteristics: While India and Zambia are extremely far apart geographically, there is a similar culture of seeking eye care among rural populations. Although vision may be declining, patients in rural India do not pursue treatment due to poor service levels

[27] World Bank Group. (2018). *GDP per capita (current US$)*, World Bank national accounts data, and OECD National Accounts data files. Retrieved April 5, 2018

[28] ICER based upon costs of patients that purchased spectacles to have the most aligned comparison with Zambia's ICER.

and financial constraints.[29] Similarly, Zambian patients wait until they are virtually blind until they seek care.[30] This likeness is a shared mentality throughout developing countries in deciding to see an eye care professional, which may result in similar levels of utility gain after a patient's self-assessment. In contrast, QALY gains are much smaller in developed countries where patients are treated for vision problems much sooner, resulting in a smaller QALY gain.[31]

Cost of Services: At two of the three hospitals in Zambia, services were free if patients were referred from a primary health facility. Through the Sight Savers program, patients that could not afford spectacles were either provided them free of charge or at a substantially discounted rate of approximately $2-3.[32] This is similar to LVPEI VC patients, who receive a free screening and a subsidized cost of spectacles. Taking each patient to be an economically rational consumer, it would be expected that a paid surgery would make a larger impact on a person's life than if it were free. Since services were free or subsidized in both populations, a similar utility value is expected.

Access to Screening: All patients recruited for the study in Zambia were a part of the Livingstone to Lusaka Urban Comprehensive Eye Care Project, which consisted of outreach services to patients that would likely otherwise not seek treatment. This is similar to LVPEI's rural-eye care networks, which focus on providing vision screening to underserved populations. This similarity may also lead to a similar measure of utility.

Age: The average age of an LVPEI patient undergoing refraction is 46 (median: 46), which is slightly higher than the mean age of this study at 39. Using the state-transition model, the refraction cohort was modelled starting at age 39 for five one-year cycles. QALYs are inherently biased toward proving more value to a younger person, as an older patient has fewer quality life years to be gained from that treatment.[33] Therefore, the LVPEI QALY gain may be slightly lower than this study.

There are several other factors that may potentially lead to similar or different utility values in each population, although no final assumptions may be made. Differing cultural norms of each population, as Zambia and India are quite distant, have the potential to impact utility gain. Further, 62% of presbyopia patients and 39% of RE patients had higher than secondary education in Zambia, while the level of education of LVPEI patients was not collected. This disparity may potentially affect utility gain.

Occupations may also be dissimilar, which can impact the value of eyesight. The majority of LVPEI patients are in rural areas and work in agriculture, while the reference study's population was both urban and rural. This could indicate varying occupations that may value eyesight differently. Moreover, both populations included both literate and illiterate patients, who used a thumbprint to sign consent forms. The majority of interviews for refraction patients were conducted in English, while LVPEI patients communicated only in their native language, Telagu.

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[29] Op. Cit. Kovai, et. al. (2010)
[30] Op Cit. Griffiths, et al. (2014).
[31] Ibid.
[32] Ibid.
[33] Harris, J. (1987). QALYfying the value of life. *Journal of medical ethics, 13*, 117-123.

Lastly, a patient's travel time and perceived inconvenience in attaining care may also affect the QALY. Mean travel times to facilities in Zambia were 35 minutes, 64 minutes and 77 minutes. Jainath, Jannaram and Utnoor also cover an wide geographic range, where some patients are closer to treatment centres than others. A shorter travel time and easier access to care leads to higher motivation and less inconvenience when seeking treatment, which may lead to a lower QALY gain. The variation between the two patient populations is unknown.

4.2. Cost-Utility Analysis: Cataract Surgery

4.2.1. Cost Analysis

The total direct cost of treatment for cataract surgery on one eye for a patient that enters the LVPEI system at the vision centre level is ₹ 4,500. This includes staff costs of ₹ 2,050, supply costs of ₹ 684, operating room charges of ₹ 1,016, and other miscellaneous charges at ₹ 750. This is the cost of a manual small incision procedure, the most common type of cataract surgery performed at the secondary centre level.

Figure 12. Total Cataract Costs, ₹ of 2017

Item	Cost
Operating Room	₹ 1,016
Supply Costs	₹ 684
Labor Costs	₹ 2,050
Miscellaneous	₹ 750
Total Costs	**₹ 4,500**

Source: LVPEI Cost Data

4.2.2. Utility Analysis

The QALY used for cataract surgery was obtained from a study conducted in Madurai, India in 2013.[34] The patient sample consisted of 292 patients that received cataract surgery through phacoemulsification at Aravind Eye Hospital in Madurai, India. Aravind Eye Hospital attracts patients from an urban area. The mean age of the sample population was 61 years.

4.2.3. Utility Estimation

Data collected was on both pre-operative and post-operative vision and quality of life. Utility was estimated through the EQ-5D-3L tool measuring health-related quality of life, administered prior to surgery and one month after surgery. Life expectancies of Indian males and females were taken into account, and QALYs gained were summed in 5-year intervals from each patient's current

[34] Hong-Gam Le, J. R. (2016). A Sustainable Model For Delivering High-Quality, Efficient Cataract Surgery In Southern India. *Health Affairs, 35*(10), 1783-1790.

age to age 100. The decline of utility after the initial gain due to treatment was estimated based using the same rate of decline in the United States. Probability of a patient being alive at any given point was calculated using probability-of-death data for India.[35]

The mean utility score before surgery was 0.84, while the mean utility score after surgery was 0.88, resulting in a utility gain of 0.04. This utility gain was accounted for over the patient's mean life expectancy, which resulted in an estimated utility gain over the patient's lifetime of 0.62 QALY.[36]

4.2.4. Incremental Cost Effectiveness Ratio

Using the WHO threshold for cost-effectiveness, LVPEI is highly cost effective, since the ICER of ₹ 7,258 is more than three times less India's per capita GDP of 2017 at ₹ 1,15,074.[37] LVPEI also fares well compared to other providers in India and the neighboring region. Baltussen et al. estimated that cost-effectiveness for cataract surgery in undeveloped and developing countries in Asia should range between $77 - $175 per DALY averted (2017 USDs).[38] In a study assessing the global cost-effectiveness of cataract surgery, the average cost for manual small incision cataract surgery (MSICS) in India as of 2004 ranged between $14 to $17 in 2017 USDs).[39] As of 2004, the average cost per QALY gained was $93.[40] This cost is equivalent to $120 in 2017. The ICER of the Aravind study was $195 in 2016 USDs. Using these benchmarks, LVPEI, at $107, has a similar to lower cost per QALY gained.

Figure 13. Incremental Cost Effectiveness Ratio (ICER) for Cataract Surgery

Discounted Cost	₹ 4,500
Incremental Utility Gain	0.62
ICER	₹ 7,258

Source: Authors' calculations

This cost analysis did not involve the process conducted in the refraction cost analysis since overhead costs of the Adilabad secondary center were unavailable. Therefore, while an initial assessment of cost effectiveness using the WHO threshold and other benchmarks shows that LVPEI is highly cost-effective, a more substantive cost analysis should be conducted to confirm these results.

4.2.5. Discussion

This reference study for cataract surgery had one main limitation that could lead to slightly higher utility gain based on tools used. While the EQ-5D-3L tool is a valid measure of utility in

[35] Ibid. p. 1784.
[36] Additional details on methodology used to develop QALY can be found in Hong-Gam Le (2016).
[37] Op. Cit. World Bank (2018)
[38] Op Cit. Lansingh, Carter, Martens (2007)
[39] Original cost was standardized to 2004 USD and discounted at 3% for 12 years for 10.9 and 3% for 5 years for 13.3.
[40] Utility gain was 0.143, discounted 3% over 5 years. Kobelt et al.

patients undergoing cataract surgery and is accepted by the National Institutes of Health for use in economic analysis, it is not specific to cataract patients.[41] If a vision-specific HRQOL tool was used, there may be slightly higher gains in utility.

While the socioeconomic characteristics and age of each patient population are fairly similar, the different costs of services could lead to varying levels of utility between the reference population and that of LVPEI.

Socioeconomic Characteristics: This study was conducted in Madurai, an urban city in the south of India, which is not too far away from Telangana. Interviews were all administered in the local language, Tamil. Since most patients in this study lived in an urban area, the typical occupation of each sample population may be very different, leading to varying utility values. Moreover, the average per-capita income of Tamil Nadu state in 2014-15 in 2017 prices is ₹ 1,30,197, compared to Telangana at ₹ 1,25,832.[42] While the disparity between urban and rural areas may lead to different utility values, the close proximity of per capita income may also strengthen the likelihood of a similar utility gain between the two populations. Furthermore, 51% of patients in this study were female, whereas LVPEI's sample totaled 43%. This difference may or may not impact the perceived utility gain.

Age: The mean age of both the study sample and LVPEI vision centre patients that received cataract surgery was the same, at approximately 61 years. (LVPEI median: 65). This similar feature strengthens the application of this QALY to LVPEI's patient population.

Cost of Services: In contrast to the CUA of refraction error and treatment, the reference study limited its sample to paying patients, while the majority of LVPEI vision centre patients receive surgery at no charge. As per above, it would be expected that a paid surgery would make a larger impact on a person's life than if it were free. Therefore, there would be a larger increase in QALYs for the reference population compared to LVPEI patients.

5. Conclusions

Evidence has shown that LVPEI's model is affordable and accessible. LV Prasad's ability to fulfill the mission of its rural eye-health program lays in its capacity to reach the poorest and most isolated areas. Patient satisfaction levels and the sheer volume of patients attests to the significant impacts LVPEI has made on the lives of millions of people. Yet, decision-makers are often perplexed as to how to quantify and leverage that impact.

By assessing the impact of LVPEI's operations in terms of cost, the present document aimed to contribute to the organization's continuous self-improvement efforts. The Cost-Consequence Analysis suggests that unrecovered costs should be taken into account when assessing the performance of VCs and analyzed from a systemic perspective. The cases of Jainath, Jannaram and

[41] Op. Cit. Hong-Gam, Le (2016) p. 1785.

[42] Government of India (2017). Ministry of Statistics & Programme Implementation: Per Capita Income. Retrived on May 2, 2018 on: http://pib.nic.in/newsite/PrintRelease.aspx?relid=169546

Utnoor suggest that one high-performing VC may well cover the operating costs of two low-performing VCs. Since the primary purpose of VCs is to serve patients in areas with low population density, these results may provide insight when considering rural network expansion. Further, when cross-subsidies are taken into account, the cost of positively changing a patient's quality of life is fairly low.

Moreover, the Cost-Effectiveness Analysis suggests that the two main treatments provided to rural communities, refractive error correction and cataract surgery, are on par or above international standards. These results contribute to the existing literature on cost effectiveness of eye care and allow for comparison with other providers and treatments.

The SAIS Practicum Team performed the most rigorous study possible given the scope of this project. While the findings are important and interesting, there are limitations to its conclusions given limited time and resources. Methodologies for both the Cost-Consequence Analysis and the Cost-Utility Analysis would ideally entail more extensive and detailed fieldwork, reaching a larger sample on multiple, separate occasions, and utilizing a more standardized data collection tool. For instance, the opportunity to develop a QALY that is specific to LVPEI would be very beneficial for exploring this area further. Additionally, a more comprehensive cost assessment of each treatment along with corresponding VC operating costs would complement this analysis. The limitations of the study, however, do not undermine the validity of its findings. Rather, they serve as a starting point for future research opportunities.

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7. Appendix

Figure A1. Total Refractive Error Costs based on Patients that Purchased Spectacles, 2017 Rupees

	Jainath	Jannaram	Utnoor
Overhead Costs	₹ 17	₹ 40	₹ 22
Capital Costs	₹ 176	₹ 134	₹ 76
Subtotal	₹ 193	₹ 174	₹ 98
Treatment Specific Costs			
Miscellaneous Costs	₹ 231	₹ 231	₹ 231
Supply Costs	₹ 260	₹ 260	₹ 260
Labor Costs	₹ 360	₹ 360	₹ 360
Subtotal	₹ 851	₹ 851	₹ 851
Total Costs to LVPEI	₹ 1,044	₹ 1,025	₹ 949
Discounted at 3% for 5 years	₹ 900	₹ 884	₹ 819
Patient Costs			
Direct Costs	₹ 132	₹ 132	₹ 132
Indirect Costs	₹ 102	₹ 102	₹ 102
Subtotal	₹ 234	₹ 234	₹ 396
Total Costs to LVPEI & Patient	₹ 1,278	₹ 1,259	₹ 1,345
Discounted at 3% for 5 years	₹ 1,102	₹ 1,086	₹ 1,160

Source: LVPEI Cost Data, 2017, & Kovai et al (2010) – Authors' calculations

Figure A2. Incremental Cost Effectiveness Ratio (ICER) for Refractive Error based on Purchased Spectacles

Method		Jainath	Jannaram	Utnoor
Including Patient Cost	Discounted Cost	₹ 1,102	₹ 1,086	₹ 1,021
	Incremental Utility Gain	0.192	0.192	0.192
	ICER	₹ 5,740	₹ 5,655	₹ 5,316
	Average ICER		₹ 5,552	
Excluding Patient Cost	Discounted Cost	₹ 900	₹ 884	₹ 819
	Incremental Utility Gain	0.192	0.192	0.192
	ICER	₹ 4,689	₹ 4,604	₹ 4,264
	Average ICER		₹ 4,549	

Source: Authors' calculations