KALINGA EYE HOSPITAL, SUBDIVISION OF NYSASDRI

Outreach and Healing

A general look at the data from outreach camps and cataract surgeries

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Synopsis

This project was undertaken in order to analyze the data associated with patients receiving free cataract-removal surgery at Kalinga Eye Hospital after being identified at one of the organization's outreach camps. Some issues that were explored were whether factors such as age had any impact on the outcome of surgery and whether we could discern any trends related to eye health and geographic locations.

Notes on Methodology

logMAR Notation

Before delving into the results of the analysis, it is worth mentioning what the established literature has to say about performing calculations on vision measurements and some assumptions that were made in order to facilitate this project. Probably the most important contribution to our methodology was the writing of Dr. Holladay, who identified that while it was possible to calculate statistics such as average visual acuities, most of the established literature up to his publishing had done so incorrectly (Holladay, 2004). Errors arose out of researchers failing to account for the fact that the Snellen scale of visual acuity proceeds in geometric as opposed to arithmetic steps; while this makes sense in terms of capturing the way that human eyesight works, it necessitates the calculation of geometric as opposed to arithmetic means.

As a solution to this problem (and to open up the possibility of more advanced statistical analysis), Holladay recommends converting Snellen measurements to the logMAR scale (ibid). The calculation is straightforward—one simply converts the Snellen ratio into decimal form and takes the negative log of the result. For example, someone with 6/6 vision would have a visual acuity of –log(6/6) = -log(1) = 0, while someone with 6/36 vision would have –log(6/36) = -log(0.16666667) = 0.77815 under logMAR notation. If one prefers to interpret results in terms of the Snellen scale, one simply has to take the antilog of the logMAR value and convert the decimal form to the appropriate fractional form. Note that there is aninverse relationship between logMAR ratings and visual acuity (high values are associated with worse vision).

The logMAR notation converts measurements that follow a geometric progression to a more straightforward arithmetic form. This allows us to calculate the arithmetic mean of visual acuity of different groups from our dataset and employ other statistical functions. It also gives us a tool to measure the change in visual acuity that might come about as a result of cataract surgery; by simply subtracting the post operation visual acuity from the pre operation visual acuitywe can develop a sense of how much the patient has improved. This is mainly useful for comparative purposes; e.g. hypothetically we might find that there are different mean improvements depending on the type of operation used. It makes less sense to convert these changes to their Snellen equivalents when attempting to interpret the results—what does it mean to say that a patient's vision has improved by 6/30?

For all of the reasons cited above, during our analysis we converted the Snellen measurements of Kalinga's datasets to their logMAR equivalents before performing any calculations. In the results section we convert these logMAR values back into the Snellen scale where appropriate (such as in the case of comparing mean visual acuities across groups), and leave the logMAR values when it is not (such as when discussing visual improvement post-surgery). In the case of a patient being rated as being able to count fingers at 1, 2,3,etc. feet, we once again follow Dr. Holladay's example and assume that the fingers are approximately the size of a 200 letter—under this system then a person able to count fingers at 2 feet would be said to have 2/200 vision (ibid). As for being able to detect hand motion, Dr. Holladay claims that hand motion is 10 times worse than counting fingers (ibid). Since staff members at Kalinga typically wave their hands directly in front of the patient's face, we approximate this distance to be 6 inches. Thus, a patient who is rated as detecting hand motion would have 0.5/2000 = 1/4000 vision under the Snellen scale. In both cases these Snellen values are converted to logMAR using the process outlined above. As for being able to detect light, in the scientific literature this rating is not considered a true measure of visual acuity, and patients with this rating have been dropped from analysis as recommended by the literature (ibid).

Variables

Our chief variables of focus then were *pre_op_treated*, *change_vision*, *camp_place*, *date*, *age*, and *improved*, which are detailed below:

- *pre_op_treated*: Indicates the visual acuity of the eye being treated as measured prior to surgery. Statistical calculations were done while this rating was in logMAR form, but for the purposes of this report the variable is typically converted back into the metric Snellen equivalent.
- *change_vision*: Calculated by subtracting *pre_op_treated* from the visual acuity of the eye as measured after surgery. Gives an indication of how much a patient's vision has

improved in the immediate aftermath of surgery. Due to the difficulty of interpreting Snellen values as a measure of change, this variable is typically reported in logMAR form. It is important to keep in mind that, due to the inverse relationship between logMAR values and visual acuity, negative values of *change_vision* correspond to an improvement in visual acuity. A positive value in *change_vision* would indicate that the patient's vision worsened after the surgery. Patients who start off with a visual acuity rating of being to detect light do not have a *change_vision* value, as there is no valid logMAR value associated with their pre-operative visual acuity.

- *camp_place*: The name of the camp where the patient was identified for treatment.
- *date*: Date of the surgery.
- *age*: Age of the patient.
- *improved*: A binary variable coded as a 1 if the difference between post-operative vision and pre-operative vision was less than zero (since under the logMAR scale a decrease in the logMAR value indicates improving vision) and 0 if this difference was greater than or equal to zero. While patients rated as being able to detect light were dropped from many stages of the analysis, for *improved* they were coded as a 1 if after surgery they received a visual acuity rating better than light detection.

Dataset

The data used in this analysis came from records pertaining to patients who received free cataract removal surgeries at Kalinga Eye Hospital after being identified at an outreach camp. This dataset covers the time period from January 21st to June 16th of 2013, with a total of 1,322 observations. Due to some missing values (and the fact that patients who were rated with a visual acuity of being able to detect light were dropped from some analyses as mentioned above) there were a total of 781 usable observations for *change_vision*, 1,018 usable observations for *pre_op_vision*, 915usable observations for *improved*, and 1,332 for the remaining variables.

Results and Preliminary Conclusions

General Descriptive Statistics

This first section of results is an attempt to characterize the nature of the dataset—no statistical methods more advanced than computing means and standard deviations were used.

The primary use of this section is to capture an overall picture of the activity of the outreach camps for future planning purposes.

Table 1 summarizes the number of patients who were identified as having cataracts at each camp location and who were brought back to Kalinga for surgery. For planning purposes it seems useful to know that Patana accounted for nearly 10% of all cases, while camps Ransol and Delanga bring in only a fraction of that amount. Without data regarding how densely populated the area is around each camp it is impossible to draw any deep conclusions regarding the incidence rate of eye disease in these areas—it may be possible that Patana simply has a greater population than the other camp areas, or there may be something in the environment contributing to the development of cataracts. Ransol may be in an isolated area, or perhaps Kalinga's advertising efforts are failing in that area. These seem like worthwhile questions to explore with more robust population data.

Table 1

Variable		Value	Frequency Count	Percent of Total Frequency
camp_place		Patana	125	9.455
		Harichandan pur	117	8.850
		Ghatagoan	94	7.110
		Keonjhar	72	5.446
		Telkoi	67	5.068
		Balikuda	61	4.614
		Rajkanika	57	4.312
		Chhatabar	45	3.404
		Pandapada	45	3.404
		Dhenkikot	43	3.253
		Suakati, Keonjhar	43	3.253
		Korei & Pachhikote	41	3.101
		Parjanga & Kumusi	41	3.101
		Danagadi Hospital	38	2.874
		Alli &Sanamanga	35	2.648
		Bhuban & Mathakaragala	33	2.496
		Boinda	31	2.345
		Barada & Sarangi	30	2.269
		Bhuban	28	2.118
		Sukinda Hospital	28	2.118
		Kantapal Panchayat Office	27	2.042
		Rasol	27	2.042

		Joranda & Baisian	25	1.891
		Gobardhanpur	24	1.815
		Rengali hospital	23	1.740
		Rahadinga & Manijunga	20	1.513
		Nihalprasad	19	1.437
		Rairakhol	18	1.362
		Sainkul	16	1.210
		Sukinda &Kuhika P.H.C	15	1.135
		Delanga	14	1.059
		Letheka & Chandia	11	0.832
		Ransol	9	0.681

Table 2 is a similar frequency table detailing the number of cases treated per date.

Table 2

Variable		Value	Frequency Count	Percent of Total Frequency
date		20.04.2013	77	5.825
		20.03.2013	75	5.673
		15.04.2013	67	5.068
		23.04.2013	50	3.782
		21.04.2013	48	3.631
		17.03.2013	45	3.404
		18.03.2013	45	3.404
		24.04.2013	44	3.328
		10.02.2013	43	3.253
		17.04.2013	43	3.253
		11.02.2013	42	3.177
		05.03.2013	41	3.101
		18.02.2013	41	3.101
		27.02.2013	41	3.101
		8.02.2013	41	3.101
		5.02.2013	40	3.026
		25.02.2013	38	2.874
		14.03.2013	35	2.648
		9.02.2013	33	2.496
		10.04.2013	31	2.345
		21.01.2013	31	2.345
		25.03.2013	30	2.269
		23.02.2013	28	2.118
		13.02.2013	27	2.042
		24.01.2013	27	2.042
		26.03.2013	25	1.891

		23.03.2013	24	1.815
		20.02.2013	23	1.740
		14.07.2013	20	1.513
		16.07.2013	20	1.513
		28.02.2013	19	1.437
		06.03.2013	18	1.362
		12.03.2013	17	1.286
		11.07.2013	16	1.210
		21.03.2013	15	1.135
		08.03.2013	14	1.059
		13.04.2013	14	1.059
		28.04.2013	14	1.059
		29.01.2013	11	0.832
		04.03.2013	9	0.681

Table 3 is a frequency table for *improved*. The most noteworthy issue here is that 30% of cases are missing values that allow us to conclude how to encode this variable. After examining the data, the only cases in which *improved* has a missing value is when a patient is missing a visual acuity rating for either pre or post surgery (there is also the possibility that visual acuity is being misreported for the wrong eye during data entry). More diligent recording of visual acuities is likely to increase the usefulness of this statistic in the future. As it stands, we can definitively state that of the 1,322 cases in the dataset, 66% of them led to greater visual acuity for the patient. The actual success rate of surgeries is likely to be much higher—dropping the missing values gives us a success rate of 870/915 = 95%, which may be closer to the truth.

Table 3

Variable	Value	Frequency Count	Percent of Total Frequency
improved	1	870	65.809
	.	407	30.787
	0	45	3.404

The average age of the patients was 65.03 years with a standard deviation of 0.2779, the average vision for the treated eye before surgery was 1.65 in logMAR (approximately 6/272 in metric Snellen) and the average change was -0.85 in logMAR. This information is summarized in Table 4. From this we can conclude that the “typical” patient treated as a result of an outreach camp is approximately 65 years old with a visual acuity of 6/272 in the eye that is being treated, and that after surgery they can expect their vision to improve to 6/38 in that eye, equivalent to a 52% improvement in eyesight. Note that this is simply based on the visual acuity test that is conducted the day after surgery—it is very possible that this improvement is even greater once the eye is given time to heal. Also, it is worth noting that the average preoperative visual acuity and change in visual acuity includes those patients who are only able to count fingers and detect hand motion as well as those who received a Snellen rating (they do not, however, include patients that can only detect light).

Table 4

Variable	N	Min	Mean	Median	Max	StdMean
age	1321	8.00	65.03	65.00	90.00	0.2779

Variable	N		Total	Min	Mean	Median	Max	StdMean
change_vision	781		-667.75	-3.43	-0.85	-0.70	1.30	0.0269

Variable	N	Total	Min	Mean	Median	Max	StdMean
pre_op_treated	1018	1684.04	0.18	1.65	1.48	3.60	0.0243

Linear Regressions

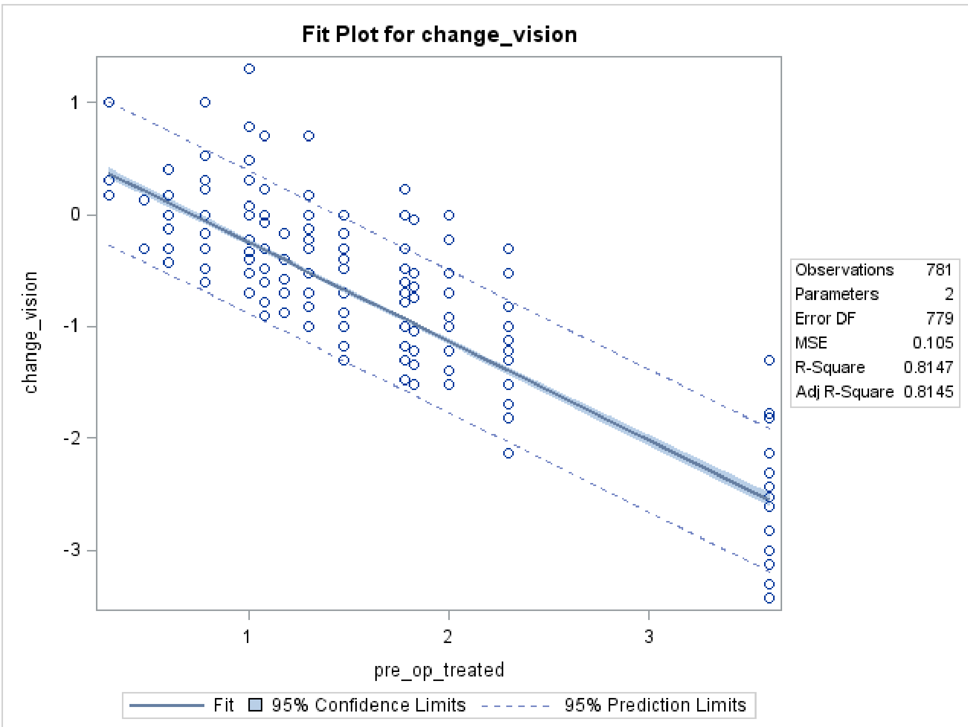
To begin a deeper analysis, we decided to examine what we expected would be an obvious and self-evident relationship between two variables and see if the data supported our intuition. Specifically, we ran a regression to determine if there was any relationship between a patient's pre-operative visual acuity (independent variable) and their post-operative vision (dependent variable). Since the procedure itself involves replacing the clouded lens with a completely clear artificial lens, we would expect that patients would more or less have similar post-operative visual acuity regardless of their starting vision (cite medical literature on this). Therefore, those with particularly poor eyesight before the operation should expect to see a more dramatic change in vision than their counterparts with less severe cataracts, implying a negative relationship between *pre_op_treated* and *change_vision*.

This conclusion is strongly supported by the data. Table 5 details the results of the linear regression of *change_vision* vs. *pre_op_treated*, and Figure 1 presents a visual representation of this relationship. The downward slope in Figure 1 shows that as *pre_op_treated* increases (i.e. pre-operative vision gets worse) the expected value of *change_vision* becomes more negative (i.e. the improvement in postoperative vision is more dramatic). This relationship is statistically significant at the 99% level and the R squared value of 0.8147 shows that pre-operative vision is a good predictor of the level of improvement that a patient can expect to experience after surgery.

Table 5

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	0.63037	0.02790	22.59	<.0001
pre_op_treated	1	-0.88264	0.01508	-58.53	<.0001

Figure 1



Having verified the important effect that *pre_op_treated* has on the outcome of surgery, we then decided to examine whether or not a patient's age would also have an effect. We therefore ran a multivariate regression with *pre_op_treated*and *age* as explanatory variables and *change_vision* as the dependent variable. The results are summarized in Table 6.

Table 6

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	1	0.33186	0.08288	4.00	<.0001
pre_op_treated		1	-0.87922	0.01498	-58.70	<.0001
age	Age	1	0.00450	0.00118	3.82	0.0001

Essentially, this tells us that even after controlling for the effects of a patient's preoperative vision, the age of a patient has a measurable effect on the amount of improvement they can expect to experience that is statistically significant at the 99% level. The coefficient of 0.00450 tells us that as a person ages one year, the amount that they can expect their vision to improve decreases by 0.00450 logMAR units. This is certainly difficult to conceptualize, so perhaps a hypothetical example is appropriate here. Suppose a patient is 65 years old and has a visual acuity of 6/272 in his eye with cataracts. According to our model, if the patient opts for surgery immediately he can expect his immediate postoperative vision to be 6/40. However, if he decides to wait ten years (and assuming that his vision remains more or less the same), his immediate postoperative vision is expected to be only 6/45, a difference of roughly 5%. Whether or not this is of any practical significance depends upon the individual in question, but this effect is measurable and statistically significant.

Finally, we also ran a regression that included the date of surgery as a third explanatory variable, with the results summarized in Table 7.

Table 7

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	1	14.91292	4.72438	3.16	0.0017
numeric_date		1	-0.00092352	0.00029918	-3.09	0.0021
pre_op_treated		1	-0.87963	0.01490	-59.05	<.0001
age	Age	1	0.00446	0.00117	3.81	0.0002

This tells us that there is some evidence that the date on which a surgery is performed has some influence on the change in visual acuity that a patient can expect to experience, with later surgeries leading to slightly better results than previous surgeries. While this influence is statistically significant, it seems to have a very small practical significance; each day decreases the value of *change_vision* by only 0.0009 logMAR units. To put this in perspective, this means that the passing of 100 days changes the expected improvement in vision by 0.09 logMAR units, roughly equivalent to the difference between 6/30 and 6/25. Thus it appears that the passage of a few months does seem to have a measurable, albeit slight, impact on the level of improvement that patients experience. Whether or not the practical significance is high enough to warrant further investigation is a question best left to the hospital administrators.

ANOVA Comparison of Mean Preoperative Vision by Camp Location

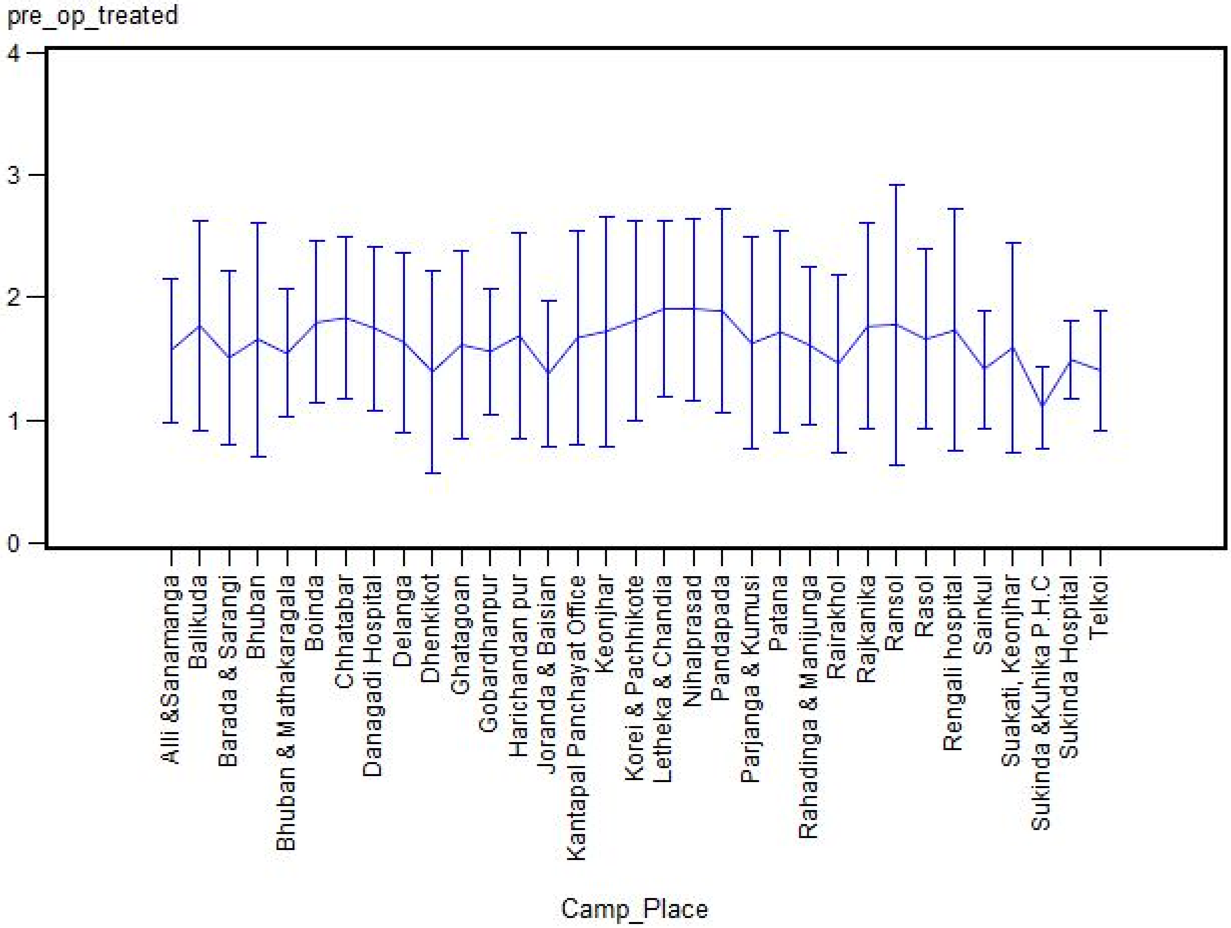
One question that seemed worth exploring was whether or not patients identified at particular campsites had significantly different average visual acuities. Significant differences in the mean value of *pre_op_treated* separated out by *camp_place* might indicate environmental factors that are affecting the development rate of cataracts for different regions in Odisha.

As it turns out, however, running an ANOVA comparison of the mean values of *pre_op_treated* by *camp_place* reveals that there is no statistically significant difference amongst the campsites' means visual acuity ratings. Table 8 shows the mean value of preoperative visual acuity by camp location while Figure 2 displays the same information in graphical form.

Table 8

Camp_Place	Mean of pre_op_treated
	1.6542665643
Alli &Sanamanga	1.568008068
Balikuda	1.7693108147
Barada & Sarangi	1.5073374092
Bhuban	1.6581999977
Bhuban & Mathakaragala	1.5420934249
Boinda	1.795322562
Chhatabar	1.8322750704
Danagadi Hospital	1.7488059829
Delanga	1.6361787474
Dhenkikot	1.3930686355
Ghatagoan	1.613002126
Gobardhanpur	1.5594876235
Harichandan pur	1.6864513686
Joranda & Baisian	1.3771530129
Kantapal Panchayat Office	1.671931963
Keonjhar	1.7235149153
Korei & Pachhikote	1.8115015803
Letheka & Chandia	1.908228609
Nihalprasad	1.9060430351
Pandapada	1.8884258321
Parjanga & Kumusi	1.6246390306
Patana	1.7174924373
Rahadinga & Manijunga	1.6104810273
Rairakhol	1.461382017
Rajkanika	1.7638207548
Ransol	1.7774768714
Rasol	1.6589319024
Rengali hospital	1.7327858064

Sainkul	1.4160184589
Suakati, Keonjhar	1.5923809661
Sukinda &Kuhika P.H.C	1.1059139578
Sukinda Hospital	1.4910273875
Telkoi	1.4055521013

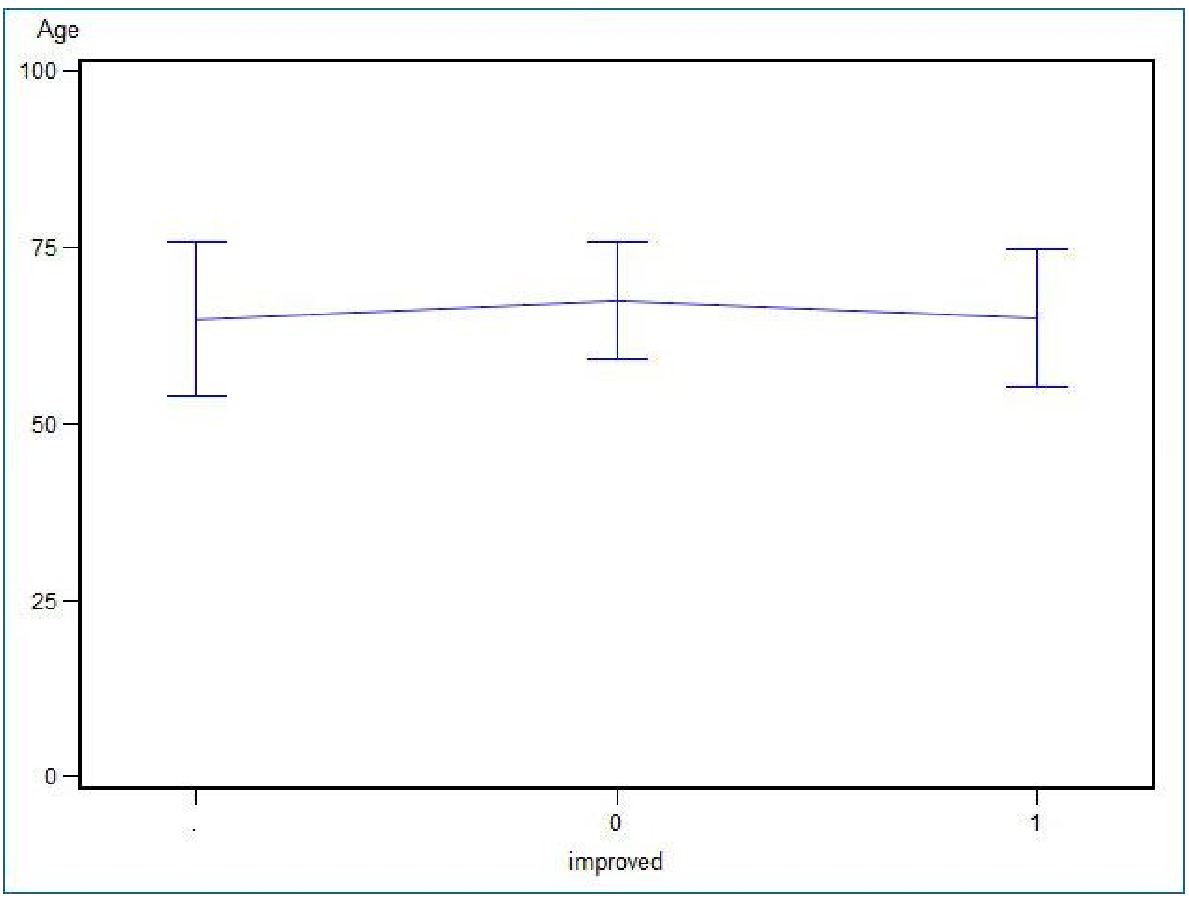


The extreme values of average visual acuity are found in Nihalprasad, which had an average preoperative acuity of 1.91 logMAR (6/496 metric Snellen), and in Joranda & Baisian, which had a preoperative acuity of 1.38 logMAR (6/146 metric Snellen). From a practical standpoint this difference does seem noteworthy, and may call for further investigation despite the statistical insignificance of this difference.

ANOVA Comparison of Mean Age Separated by Successful Surgery

Finally, since earlier we discovered there was a measurable relationship between a patient's age and the amount their vision improved post-surgery, we decided to examine whether the average age was significantly different amongst groups of patients separated out based upon the success or failure of the surgery. For this we separated the dataset into groups based upon the variable *improved*, which is coded as a 1 (success) if the patient's vision improved after surgery and 0 (failure) if it got worse or stayed the same. Ideally this would split the patients into two categories, however due to the previously noted missing data we actually have three groups; one for *improved=1*, one for *improved=0*, and one for *improved* is not available, indicated by "." in the results.

Despite the influence that age has on *change_vision*, our analysis shows that a patient's age has no bearing on whether or not he will experience at least *some* degree of improvement. The graph below shows the marginal difference in the average age between the different categories of *improved*.



Conclusions and Further Steps

Overall, it seems that the most significant results of this project can be found in the profile of the “typical” patient receiving free cataract surgery from Kalinga along with the effects that a patient’s age and the date of the surgery have on the expected level of visual improvement. Also, while the results were not statistically significant, it may prove useful to investigate potential causes behind the practically high level of visual impairment identified in Nihalprasad.

Future attempts at similar analysis would be improved by ensuring that each and every patient has a recorded value for pre and postoperative vision for the treated eye. Also, in this analysis the results are based upon postoperative visual acuity that was taken the day following surgery. It may prove illuminating, if it is possible to collect the data, to see if the results are changed by using postoperative acuity taken several months after surgery, after the healing process has ended.