Statistical Analysis On Kidney Transplantation And Donation In India

[1]Aqila Nazifa, [2]Likhitha D Atada, [3]M.S.Suma

[1]Student, [2]Student, [3]Professor
[1]Department of Medical Electronics Engineering,
[1]B.M.S. College of Engineering, Bengaluru, India

***Abstract*—Organ transplantation is the process of surgically removing an organ from one individual and placing it in the body of another individual. Kidney transplantation is the process of transferring a kidney when one fails to operate. There are two types of donors: One is a living donor and the other is a deceased donor. The statistical analysis of kidney transplants and donors is performed. The analysis is performed for year-wise transplants, and donors based on gender, age, and state-wise donors. Biostatistics technique such as correlation, regression, and hypothesis testing is performed on the collected data. The results conclude the population-based statistical analysis of kidney transplants in India.**

***Index Terms*—kidney, transplants, donors, live donors, deceased donors, recipient**

I. INTRODUCTION

Organ transplant has gained popularity in these recent years. When one of the kidneys fails to operate there are two treatments given, one is dialysis and the other is a kidney transplant. Dialysis is performed on a daily basis as it acts as a kidney only for 10% whereas transplantation of a kidney works for 10 years. As per the National Organ and Tissue Transplant Organization (NOTTO), the PAN-India deceased organ donation rate is at 0.34 per million population (PMP) which stands as the lowest in the world. While 1.8 lakh people suffer from renal or kidney failure, only 6,000 renal transplants are conducted annually. In the current situation in India, the number of patients requiring kidney transplantation is estimated to be about 220,000 annually.

While 70 donations were recorded in 2021, 72 have been recorded in the first six months of 2022. According to the World Health Organization, only around 0.01 percent of people in India donate their organs after death. Currently, approximately 7500 kidney transplantations are performed at 250 kidney transplant centers in India. Of these, 90% come from living donors and 10% from deceased donors. The success rate of kidney transplants in India is one of the highest in the world. The current success rate is about 90 percent.

II. OBJECTIVE

The general objective of this study is to identify the important parameters according to the data collected from the Indian Transplant Registry and conclude the changes observed in transplants and donors.
The specific goals of this work are

- Performing hypothesis testing on the year-wise transplantation and age group data.
- Apply least square correlation for state-wise ranking data and gender-based data.

III. HYPOTHESIS

This work proposes the following hypothesis:

1. According to data obtained from the Indian transplant registry, it shows a significant increase in the number of transplants between the years 1971 to 2015.
2. There is a linear Correlation with respect to year and transplants.
3. State-wise ranking correlation between live and deceased donors.
4. According to the registry, the age group 21- 60 has more organ donors. Recipients are more between the ages of 21-30.

IV. THEORETICAL FRAMEWORK

- Pearson's correlation:

  The Pearson correlation coefficient is a representative way to measure similarity [4]. It is the ratio of the covariance to the standard deviation. It has relatively high requirements for the data.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (1)$$

  - ➔ r = Pearson Coefficient
  - ➔ n= number of pairs of the stock
  - ➔ ∑xy = sum of products of the paired stocks
  - ➔ ∑x = sum of the x scores
  - ➔ ∑y= sum of the y scores
  - ➔ ∑x2 = sum of the squared x scores
  - ➔ ∑y2 = sum of the squared y scores

- Spearman's rank correlation coefficient:

  This is used for ranking continuous data and also in ordinal data. When ranking the data, ties (two or more subjects having exactly the same value) then the average of rank is taken and assigned.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (2)$$

  ➔ di is the difference between a pair of ranks
  ➔ n is the number of observations

- Hypothesis testing;

  The Student's t-test is widely used when the sample size is reasonably small (less than approximately 30). In these cases, the sample distribution of the mean is known to follow a t-distribution. The upper and lower bounds values of confidence intervals are compared with the t value obtained. If it lies in the range, then the hypothesis is correct or accepted

$$t = \frac{\bar{x} + \mu}{\frac{\sigma^2}{\sqrt{n}}} \rightarrow$$

where,
'x' bar is the mean of the sample,
μ is the assumed mean,
σ is the standard deviation,
and n is the number of observations.

$$t = \frac{\overline{X1} - \overline{X2}}{\sqrt{\frac{(n1-1)\sigma 1^2 + (n2-1)\sigma 2^2}{n1+n2-2}} \times \sqrt{\frac{1}{n1} + \frac{1}{n2}}} \quad (3)$$

V. METHODOLOGY

1. Collection of data: The data was collected from the Indian society of organ transplantation year-wise, state-wise, gender-wise, and for different age groups. The data has details containing the main factors and it has information from the year 1971.
2. For increased transplantation with respect to year, linear regression analysis was performed. The least square regression with a correlation of year and transplant was used for obtaining the increment in the transplantation according to the year. The live donor and deceased donor data were separately taken and plotted with respect to the year.

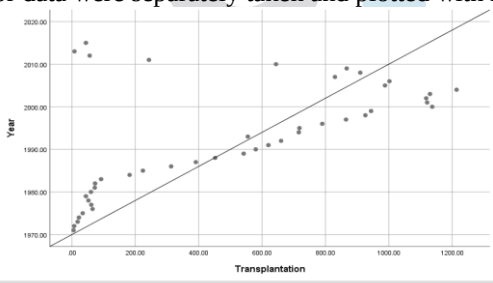

Fig1: Correlation graph between year and transplants

Correlations

		Transplantation	Year
Pearson Correlation	Transplantation	1.000	.598
	Year	.598	1.000
Sig. (1-tailed)	Transplantation	.	.000
	Year	.000	.
N	Transplantation	44	44
	Year	44	44

Descriptive Statistics

	Mean	Std. Deviation	N
Transplantation	486.2500	413.64602	44
Year	1992.5227	12.88498	44

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			
					R Square Change	F Change	df1	df2	Sig. F Change
1	.598[a]	.358	.343	335.33493	.358	23.429	1	42	.000

a. Predictors: (Constant), Year

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2634550.583	1	2634550.583	23.429	.000[b]
	Residual	4722879.667	42	112449.516		
	Total	7357430.250	43			

a. Dependent Variable: Transplantation

b. Predictors: (Constant), Year

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-37790.808	7908.115		-4.779	.000					
	Year	19.210	3.969	.598	4.840	.000	.598	.598	.598	1.000	1.000

a. Dependent Variable: Transplantation

Fig 2. Regression analysis. a.Descriptive Statistics b. Pearson's correlation, c. Model summary, d.ANOVA, e. Coefficients

The correlation graph between year and transplantation is shown in Fig 1. Pearson's correlation coefficient was 0.598 which shows that there is a positive correlation. That means there is a linear increment in transplantation. The least square regression was obtained as 0.3 as shown in the model summary Fig 2. c. The regression equation for live and deceased donors was shown in Fig 3.

The correlation between live donors, deceased donors, and recipients were performed and shown in Fig.5. As per the graph, it shows very less deceased donors and high live donors.

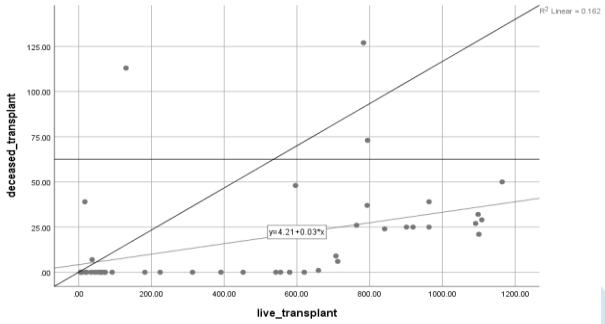

Fig 3. Regression between live donors and deceased donors

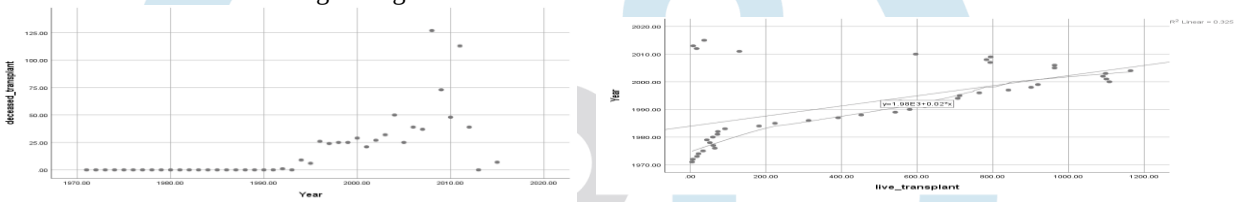

Fig 4.a.Scatter plot for deceased transplant and year and b. Scatter plot for live transplant and year.

Correlations

		Live_donar	Deceased_donar	Recipient
Live_donar	Pearson Correlation	1	.157	.911**
	Sig. (2-tailed)		.711	.002
	N	8	8	8
Deceased_donar	Pearson Correlation	.157	1	.416
	Sig. (2-tailed)	.711		.306
	N	8	8	8
Recipient	Pearson Correlation	.911**	.416	1
	Sig. (2-tailed)	.002	.306	
	N	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

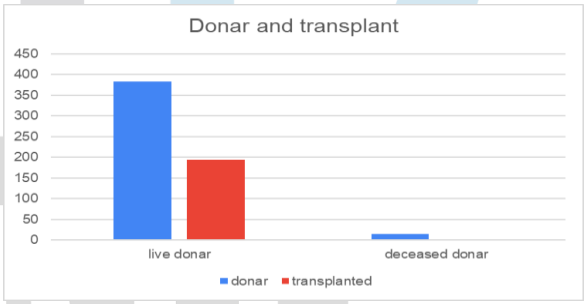

Fig 5. a. Pearson's correlation for live donors, deceased donors, and recipients and b. Bar graph representation

3. Correlation between male and female transplantation was done using Pearson's correlation method. The gender-based distribution with respect to year was plotted. The correlation coefficient was obtained using the SPSS tool.

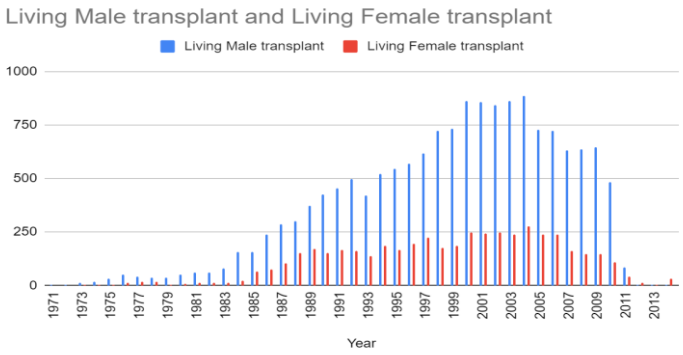

Fig 6. Representation for live male and female Transplants

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Correlations

		Year1	male_transplant	female_transplant
Pearson Correlation	Year1	1.000	.570	.553
	male_transplant	.570	1.000	.966
	female_transplant	.553	.966	1.000
Sig. (1-tailed)	Year1	.	.000	.000
	male_transplant	.000	.	.000
	female_transplant	.000	.000	.
N	Year1	44	44	44
	male_transplant	44	44	44
	female_transplant	44	44	44

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.571[a]	.326	.293	10.83713	.326	9.893	2	41	.000

a. Predictors: (Constant), female_transplant, male_transplant

b. Dependent Variable: Year1

Coefficients[a]

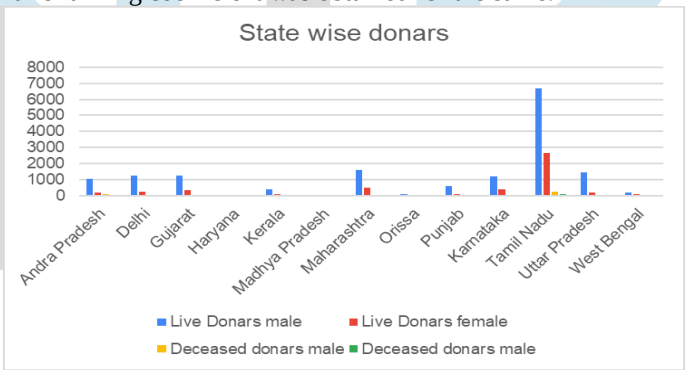
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1984.028	2.557		775.860	.000					
	male_transplant	.022	.020	.543	1.100	.278	.570	.169	.141	.068	14.810
	female_transplant	.004	.069	.029	.058	.954	.553	.009	.007	.068	14.810

a. Dependent Variable: Year1

Fig.7 Correlation between male and female Transplant with model summary and regression analysis.

The male and female distribution according to the year was shown in Fig.6 with an increased number of male donors compared to female donors. Pearson's correlation coefficient was 0.966 with fairly strong positive correlation. The regression analysis was 0.3 as in model summary fig 7.

4. For State wise ranking of live and deceased donors, the correlation coefficient using Spearman's ranking method was performed. The rank cases were sorted for male live donors, female live donors, male deceased donors, and female deceased donors. The Spearman's ranking coefficient was obtained for the same.



Correlations

			Rank of Live_donar_male	Rank of Live_donar_female	Rank of Deceased_male	Rank of Deceased_female
Spearman's rho	Rank of Live_donar_male	Correlation Coefficient	1.000	.923**	.683*	.728*
		Sig. (2-tailed)	.	.000	.042	.026
		N	13	13	9	9
	Rank of Live_donar_female	Correlation Coefficient	.923**	1.000	.500	.628
		Sig. (2-tailed)	.000	.	.170	.070
		N	13	13	9	9
	Rank of Deceased_male	Correlation Coefficient	.683*	.500	1.000	.912**
		Sig. (2-tailed)	.042	.170	.	.001
		N	9	9	9	9
	Rank of Deceased_female	Correlation Coefficient	.728*	.628	.912**	1.000
		Sig. (2-tailed)	.026	.070	.001	.
		N	9	9	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Fig 8. State-wise donors representation and correlation between their rankings

The state-wise ranking performed for live and deceased gender-based correlation was shown in fig. After sorting the ranking data, the results were obtained showing Tamil Nadu with a greater number of donors. The other states were represented using a bar plot for showing the live and deceased donors as in fig 8.

5. The Age group 21-60 has more organ transplants which were tested using a one-way sample t-test. The mean value for testing was taken as 60. For more than 60 donations, the age was considered in the region of more donations. The t-test value and the p-value were analyzed using the test results. The confidence level taken was 95%.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Live_Donar	8	47.8750	48.17064	17.03089

One-Sample Test

Test Value = 60

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Live_Donar	-.712	7	.500	-12.12500	-52.3967	28.1467

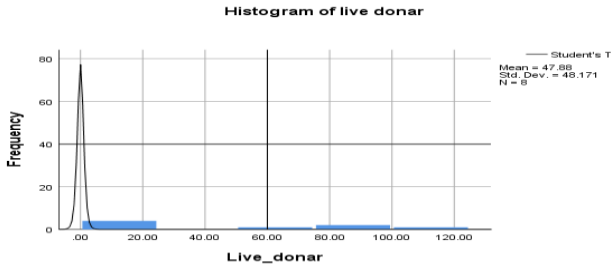


Fig 9. One-way sample t-test for mean<60 with histogram representation for live donors

The one-way sample t-test performed for the assumed mean 60 results are shown in Fig.10. The t-valve -0.712 lies in the range value of confidence level 95% proving the null hypothesis being rejected and acceptance of an alternative hypothesis. The p-value obtained is 0.5. The histogram curve with student or t-test curve is given in Fig.9.b.

6. The Age group 21- 30 has more recipients which were tested using a one-way sample t-test. The mean valve taken was 40 and the t-test value was checked with respect to a confidence level of 95%. The p-value was determined to validate the hypothesis.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Recipient	8	24.3750	18.97320	6.70804

One-Sample Test

Test Value = 40

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Recipient	-2.329	7	.053	-15.62500	-31.4870	.2370

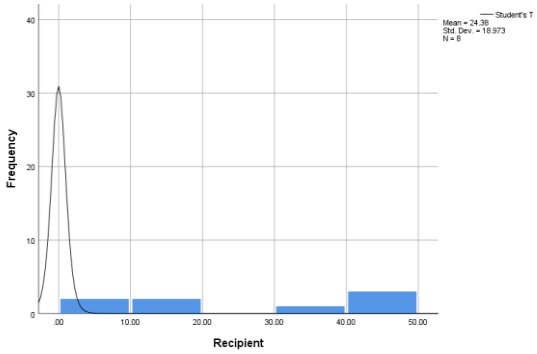


Fig 10.One-way sample t-test with mean<40 for recipients.

The recipient one-way sample test was performed with mean taking as 40. There were three regions with more than 40 recipients which were taken into consideration. But according to the hypothesis, the 21-30 age group has a higher number of recipients which was validated using SPSS. The t- value -2.329 lies in a 95% confidence level as shown in Fig.10 The alternative or assumed hypothesis was validated and the p-value obtained was 0.053. The histogram graph was displayed in Fig with a t-test curve in it.

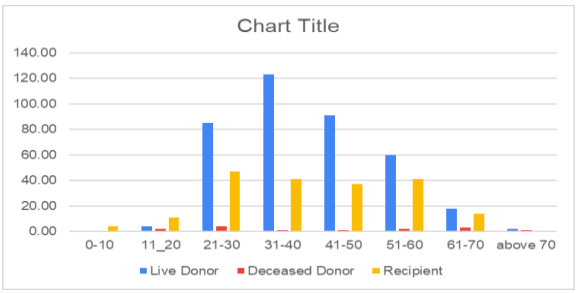


Fig 11. The bar graph representation for live donors, deceased donors, and recipients.

VI. Conclusion

Population-based analysis was performed on kidney transplants and donor data from India Transplant Registry for different parameters. From the results, it is concluded that there was a linear increase in transplantation with respect to the year. The live and deceased male and female results show that there is an increment in live donors and the deceased donors were comparatively less. In India, Tamil Nadu state showed the highest number of donors compared to other states. The hypothesis for the age group 21-60 showed a higher number of donors and the age group 21-30 showed a higher number of recipients.

VII. Acknowledgment

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