

## Cost-effectiveness analysis of dialysis and kidney transplant in patients with renal impairment using disability adjusted life years in Iran

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### Abstract

**Background:** This cross-sectional study was conducted to compare the cost-effectiveness of three therapeutic methods of long-term hemodialysis, kidney transplant from a living person and kidney transplant from a cadaver utilizing Disability Adjusted Life Years (DALY) using data from the records of patients referred to Afzalipour Hospital of Kerman in 2012.

**Methods:** This cross-sectional study utilizing Disability Adjusted Life Years (DALY) as outcome measure, used data from the records of patients referred to Afzalipour Hospital of Kerman in 2012. The decision tree model and decision tree software (Tree Age pro 11) were used for data analysis. In this research, costs and effects were studied from the patients and healthcare providers' perspective.

**Results:** In the patient's perspective, the CER of dialysis was 5.04 times greater than transplant from a living person and 6.15 times higher than transplant from a cadaveric donor. In the hospital's perspective, the average cost-effectiveness ratio of dialysis was 8.4 times greater than transplant from a living person and 14.07 times higher than transplant from a cadaver. The smaller the C-E ratio, the greater was the cost-effectiveness. In both perspectives, the order of effectiveness of treatment methods were transplant from a cadaver, transplant from a living person and dialysis.

**Conclusion:** Considering the results obtained in this study, measures should be taken to increase the desire for organ donation from brain-dead patients, living people and patients' relatives.

**Keywords:** Cost-Effectiveness, DALY, Chronic Dialysis, Kidney Transplant.

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### Introduction

With the changing face of health in the last two decades in Iran, changes can be observed in the disease patterns with the increasing trend of chronic diseases such as renal diseases (1). End-stage renal disease (ESRD) is an incurable condition with irreversible loss of kidney function (2). Renal failure is a major public health problem in

the world, which is referred to temporary or permanent kidney damage, leading to loss of normal kidney function. According to the report of the Transplant and Specific Diseases Management Center of the Ministry of Health, 320,000 people in the country suffer from renal failure; of whom, 49% use the transplantation treatment method, 48% hemodialysis and 3% use peritoneal

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dialysis method. The growing trend of this disease in the world suggests that the number of patients receiving alternative treatments such as renal transplantation, peritoneal dialysis and hemodialysis is growing as well (3).

Approximately 10 to 15 percent of the US adult population is suffering from chronic renal failure. The prevalence has been reported 11.2% in Australia, 10.1% in Singapore as a country in Southeast Asia and 18.7% in Japan (4). People with chronic renal failure initially receive protective treatment, but eventually require hemodialysis. More than one million people are surviving through dialysis worldwide (5). Renal transplantation, which is being done in our country for many years, is the treatment of choice for chronic renal failure (6). In the case of not receiving a successful kidney transplant, these patients escape from early death using new methods of treatment such as dialysis. However, they are in a wide range of physical, psychological, social and economic problems, which in general, affect their quality of life (7).

A considerable proportion of the health budget is allocated to the growing number of patients with end-stage renal diseases (ESRD). Therefore, the massive demand for renal replacement therapy costs has become a great burden for healthcare systems in developing countries. Since chronic kidney disease (CKD) and ESRD emerged as public health problems in developing countries, a change in healthcare policies was required (8).

Jensen et al. in 2014 (9), Elsharif et al. in 2010 (8), Howard et al. in Australia in 2009 (10), Perović and Janković in Serbia in 2009 (11) and Karimi et al. in 2005 performed researches in this field (12).

This cross-sectional study aimed to determine the cost-effectiveness of chronic dialysis, kidney transplantation from a cadaver and kidney transplantation from a living person in Afzalipour Hospital of Kerman province in Iran using DALY measure.

## Methods

This cross-sectional study was conducted to compare the cost and effectiveness of three therapeutic methods of long-term hemodialysis, kidney transplant from a cadaver and kidney transplant from a living person utilizing DALY measure, using data from the records of patients referred to Afzalipour Hospital of Kerman for treatment in 2012. The statistical population of the study was all the records of patients hospitalized in Afzalipour hospital for kidney transplantation in 2012, and patients who referred to this hospital for chronic dialysis since the beginning of 2012. In this study, the records of 32 chronic dialysis patients and 97 kidney recipients aged 12-84 years who underwent dialysis or kidney transplant for the first time were studied. One person was in both the transplant and dialysis groups and therefore removed due to the overlap. Dialysis group included 9 females and 23 males, and the transplant group included 30 females and 67 males. The transplant from a cadaver group included 29 patients, and the transplant from a living person group included 68 patients.

This study examined this topic from two perspectives: The costs and outcomes from the patients, and the service provider organization (Afzalipour Hospital). The data-gathering tool was a two-part predetermined form designed by the researcher. The first part of the predetermined forms included demographic characteristics, type of treatment and duration of hospitalization, fees and contact information of the patients. The second part contained such information as the starting date of dialysis or transplantation, date of death or transplant rejection, costs of monthly tests and checkups, travel costs for the patients and the person accompanying them, and accommodation costs for the person accompanying the patients, which were collected through phone or live interviews with the patients or their families (Fig. 1). Data were analyzed using the decision tree model and Tree Age Software.

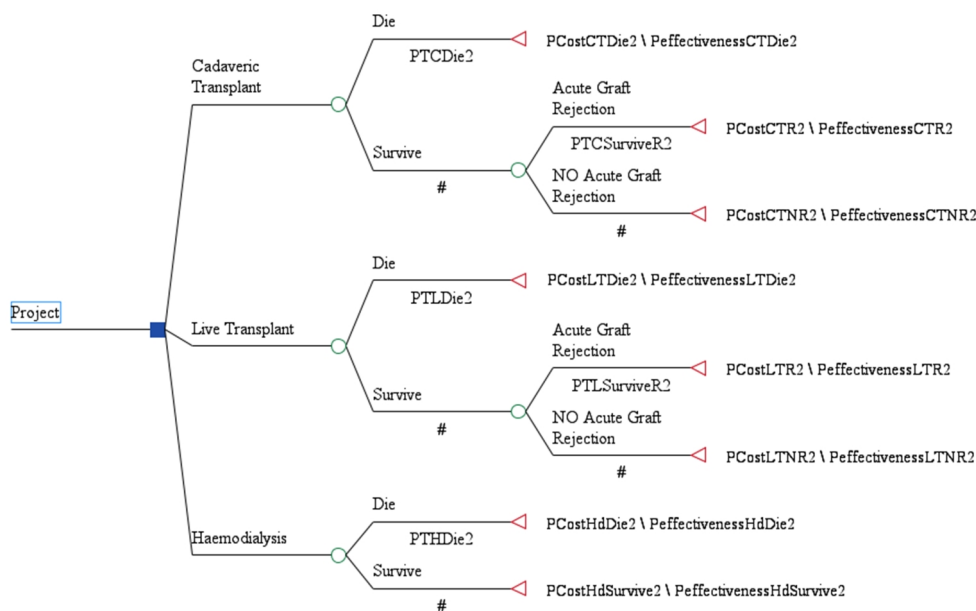


Fig. 1. Decision Tree Model for Three Methods of Transplant from a Cadaver, Transplant from a Living Person and Dialysis

**Costs**

In this study, direct medical costs (equipments used and personnel fees) and tariffs paid by the patients or the supporting centers for dialysis and kidney transplantation patients were calculated. Indirect costs including travel costs, accommodation costs and expenses resulting from the absence from work were also included. The cost of work absenteeism is equal to the daily income multiplied by the number of times of treatments.

**Effectiveness**

Effectiveness of the interventions was calculated based on DALY measure. DALY is a combination of two elements: Years lived with disability (YLD) and years of life lost (YLL).

Equation 1: Disability- Adjusted Life Year (DALY)

$$DALY = YLL + YLD$$

Equation 2: Years of life lost (YLL).

$$YLLS = \frac{KC_e^{r \cdot a}}{(r + \beta)^2} [e^{-(r + \beta)(L + a)} \{ -(r + \beta)(L + a) - 1 \} - e^{-r \cdot L}] + \frac{1 - K}{r} (1 - e^{-r \cdot L})$$

Equation 3: Years lived with disability (YLD)

$$YLD = D \frac{KC_e^{r \cdot a}}{(r + \beta)^2} [e^{-(r + \beta)(L + a)} \{ -(r + \beta)(L + a) - 1 \} - e^{-r \cdot L}]$$

“K” is the relative value of age (1), “β” is the World Bank's parameter (0.04), “C” is comparative constant (0.16243), “e” is the base of the natural logarithm, “D” is disability weight and discount rate or “r” is 0.03. “L” is the average treatment duration (in years) in YLD and raw years lost in YLL and “a” is the age having the disability in age group in YLD and age at the time of death in YLL (13). The disability weight was considered 0.155 for dialysis and 0.05 for transplantation (14). To calculate the cost and effectiveness, patients treated with the two methods of transplantation from a living person and transplantation from a cadaver were categorized into three groups of died, successful transplantation and unsuccessful transplantation; and using dialysis treatment method, they were classified into two groups of died and alive.

The long-term costs and consequences were considered from the onset of the disease until the patient's death.

*Modeling*

The cost and effectiveness per patient was entered into the Tree Age Software to plot the model considering a discount rate of 0.03 (15) as well as the possibilities. Cost-effectiveness ratio (CER) was calculated using the following equation (Equation 1, 2). In this equation, cost is the average cost per person in terms of million Rials and effectiveness is the average effectiveness per person based on DALY. Exchange rates of 2012 were used to convert currencies.

Equation 4: Average Cost Effectiveness Ratio

$$ACER = \frac{Cost}{Effectiveness}$$

Equation 5: Incremental Cost Effectiveness Ratio

$$ICER = \frac{\Delta Cost}{\Delta Effectiveness}$$

*Sensitivity Analysis*

The decision tree and tornado diagram were plotted. Considering the tornado dia-

gram, sensitivity analysis was performed for the parameters that had the greatest impact on the cost-effectiveness. One-way and two-way sensitivity analysis was performed. Performing a sensitivity analysis requires high and low ranges for parameters where these ranges were obtained with a 10% change in the parameters (16). Since some parameters were not in the decision tree model (relative value of age, disability weight and discount rate) and were pre-calculated, their sensitivity analysis was performed using excel software. Sensitivity analysis for effectiveness, cost and possibilities was performed using Tree Age Software.

**Results**

*Result by Perspective*

The results of the patient's perspective are displayed in Table 1 and the perspective of the health system in Table 2.

A) The patient's perspective

The C-E ratio in transplant from a living person was 3,181.07 dollar/DALY; it was 2,528.5 dollar/DALY in transplant from a cadaver, and 15,986.9 dollar/DALY in chronic dialysis. The cost-effectiveness ratio of dialysis was 5.04 times greater than

Table 1. Direct and Indirect Cost in the Model

Type of Treatment	Direct Costs (dollar)	Indirect Costs (dollar)	Total Costs (dollar)	Weighted Average Costs with a Discount Rate of 0.03 (dollar)	Effectiveness (DALY)	Cost-Effectiveness Ratio (dollar/DALY)	Incremental cost-effectiveness ratio (dollar /DALY)
Kidney Transplant from a Cadaveric	60848.3	85236.5	146084.8	13295.3	5.12	2528.5	0
Kidney Transplant from a Living Person	107096.2	77487.7	184584.01	19657.4	6.18	3181.07	5954.3
Chronic dialysis	1174306.7	39151.7	1213539.9	104649.3	6.52	15986.9	256525.3

Table 2. The Cost-effectiveness Ratio of the Three Studied Interventions: Kidney Transplant from a Cadaveric, Kidney Transplant from a Living Person, Chronic Dialysis (Costs in Dollar)

Type of Treatment	Direct Costs (dollar)	Weighted Average Costs with a Discount Rate of 0.03 (dollar)	Effectiveness (DALY)	Cost-Effectiveness Ratio (dollar/DALY)	Incremental cost-effectiveness ratio (dollar/DALY)
Kidney Transplant from a Cadaveric	60848.3	5628.05	5.12	1060.4	0
Kidney Transplant from a Living Person	107096.2	11419.2	6.18	1794.5	5383.4
Chronic dialysis	1174306.7	101305.05	6.52	15497.6	271288.7

transplant from a living person and 6.15 times larger than transplant from a cadaver. The smaller the C-E ratio, the greater was the cost-effectiveness; transplant from a cadaver was more cost-effective than a transplant from a living person and dialysis. Transplant from a cadaver saved more than 5,954.3 dollar/DALY compared to transplant from a living person and more than 65,171.3 dollar/DALY compared to dialysis.

#### B) The Perspective of the Health System

The C-E ratio in transplant from a living person was 1,794.5 dollar/DALY, it was 1,060.4 dollar/DALY in a transplant from a cadaver and 15,497.6 dollar/DALY in chronic dialysis. The cost-effectiveness ratio of dialysis was 8.4 times greater than transplant from a living person and 14.07 times higher than transplant from a cadaver. The smaller the C-E ratio, the greater was the cost-effectiveness; transplant from a cadaver was more cost-effective than a transplant from a living person and dialysis. Transplant from a cadaver saves more than 5,383.4 dollar/DALY compared to transplant from a living person and more than 68,352.4 dollar/DALY compared to dialysis.

Considering Table 1, Table 2, and Graph 1, it can be concluded that in both the patients and the healthcare providers' perspective, kidney transplantation from a cadaver treatment method was more cost-effective than the other two methods of transplantation from a living person and dialysis. Compared to the cost-effectiveness based on DALY measure, kidney transplant method (transplant from living person and cadaver) was far better than chronic dialysis. The superiority of kidney transplant method was 5 to 14 times the chronic dialysis. Considering the tornado diagram, one-way and two-way sensitivity analysis was performed for the parameters that had the greatest impact on the cost-effectiveness. Two-way sensitivity analysis was performed for the desired parameters in pairs with respect to tornado diagram. From the patient's perspective, these pa-

rameters were dialysis costs for a living person, the costs of a successful transplant from a living person, the effectiveness of a successful transplant from a living person, the mortal effectiveness of a transplant from a living person and the effectiveness of a successful transplant from a living person. The parameters for the hospital's perspective included the effectiveness of a successful transplant from a cadaver, the mortal effectiveness of a transplant from a cadaver, the probability of unsuccessful transplant from a cadaver, the costs of a successful transplant from a cadaver and the effectiveness of unsuccessful transplant from a cadaver. The results were not sensitive to the desired parameters, meaning that transplant from a cadaver is still superior to transplant from a living person and dialysis. In general, kidney transplant is superior to dialysis method as it causes less inability in patients.

#### Discussion

This study focused on the cost-effectiveness of dialysis, kidney transplant from a cadaver and transplant from a living person, using DALY measure. The reason for using cost-effectiveness analysis was that although dialysis and kidney transplant both increase the longevity, the obvious difference between the quality of life required comparing the benefits of the three treatment methods. The model used in this analysis calculated the cost-effectiveness of hemodialysis, transplant from a cadaver and transplant from a living person. The three outcomes of death, successful transplant and transplant rejection were considered. The results of this study revealed that kidney transplant from a cadaver is more cost-effective than the other two treatment methods of transplant from a living person and dialysis. Sensitivity analysis showed that changes in probability, costs and effectiveness did not affect the obtained results. Therefore, we suggest that kidney transplant from a cadaver is significantly better than transplant from a living person, and transplant from a living person is far better

than dialysis. According to Iran Central Bank, the reference exchange rate was 12,260 Rials in 2012 (17). The main reason for the difference between the results of this study and those of others is based on the issue of cost. In other words, the cost of medical procedures was not based on cost price.

The results of the study by Perović and Janković revealed the followings: The cost of dialysis: 22 8,161.61 dollar, the final costs of dialysis: 228,161.61 dollar; the effectiveness of dialysis: 4.83 quality-adjusted life years (CALY); and the final effectiveness of dialysis: 4.83 CALY. The cost of transplant was 67,536.7 dollar, the final costs of transplant 160,603.6 dollar; the effectiveness of transplant was 5.71 CALY and the final effectiveness of transplant was 0.88 CALY. The cost-effectiveness ratio of dialysis was estimated to be 47,226.7 dollar/DALY and the cost-effectiveness ratio of transplant was 182,463.3 dollar/DALY (11).

The results of the study by Elsharifet al. revealed that the annual costs of hemodialysis was 6847/00 dollar, the total costs of the first year after kidney transplant was 14,825/04 dollar and the costs of kidney transplant after the first year was 10,651 dollar. Total days of hospitalization and absence from work were lower in the transplant group. In Sudan, kidney transplant was less expensive than hemodialysis (8).

In Jensen's study in Denmark in 2014, the costs of dialysis was 189,529.17 dollar, the costs of transplant 148,718.53 dollar, the effectiveness of dialysis 1.7 and the effectiveness of transplant was 4.4. ICER was estimated 14,518.8 dollar/DALY which led to the saving 40,783.03 dollar/2.8 CALY compared to dialysis (9).

In the study conducted by Karimiet al. in Iran, the average costs of treatment period in the chronic dialysis method was 13,213.7 dollar for female patients and 10,114.1 dollar for male patients, and it was estimated 2,446.9 dollar for female patients and 2,283.8 dollar for male patients in the kidney transplant method. The costs of treat-

ment period for chronic dialysis were determined 859.3 dollar and 195.8 dollar for kidney transplant method. The cost-effectiveness difference between the two methods was higher in male patients (1,876.01 dollar per one DALY) compared to female patients (1,468.2 dollar per one DALY) (12).

The results obtained in this study confirmed the results of the above-mentioned studies that indicated kidney transplant is more cost-effective than dialysis. However, in contrast to the results obtained in this study, in the study by Kaminota, transplant from a living person is more cost-effective than transplant from a cadaver. In this study, the treatment methods in order of cost-effectiveness are transplant from a cadaver, transplant from a living person and dialysis.

This study has some limitations: Only patients' statements were considered in calculating the indirect costs such as the costs of traveling; there was no congruence between patients due to the lack of a sufficient number of patients in this area; moreover, we used the discount rate of 0.03 from other studies because discount rate has not been calculated in Iran.

Given the results of this study, the culture of organ donation from brain dead patients should be promoted because only 30% of the families of brain dead patients consent to organ donation three out of every 10 people). In general, considering the findings of this study, measures should be taken to increase the tendency for organ donation from brain dead and living individuals and family members of the patients. Transplantation from a living donor could be considered due to the long waiting time of patients and lack of donated organs. This study suggests kidney transplant more than dialysis as it results in better quality of life and higher life expectancy.

### Conclusion

The results of this study with respect to both the patients and the healthcare providers' perspectives suggest that transplant

from a cadaver is more cost-effective than the other two treatment methods of transplant from a living person and dialysis. We suggest that measures be implemented to increase the desire for organ donation from brain dead patients, living people and patients' relatives. Moreover, the government should allocate more resources to kidney transplant programs.

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