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Policy Perspective

Projecting the Economic Impact of Compensating Living Kidney Donors in the United States: Cost-Benefit Analysis Demonstrates Substantial Patient and Societal Gains

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ABSTRACT

Objectives: The aim of this study was to show how the US government could save approximately 47 000 patients with chronic kidney failure each year from suffering on dialysis and premature death by compensating living kidney donors enough to completely end the kidney shortage.

Methods: Supply and demand analysis was used to estimate the number of donated kidneys needed to end the kidney shortage and the level of compensation required to encourage this number of donations. These results were then input into a detailed cost-benefit analysis to estimate the economic value of kidney transplantation to (1) the average kidney recipient and their caregiver, (2) taxpayers, and (3) society in general.

Results: We estimate half of patients diagnosed with kidney failure each year—approximately 62 000 patients—could be saved from suffering on dialysis and premature death if they could receive an average of $1^1/_2$ kidney transplants. However, currently there are only enough donated kidneys to save approximately 15 000 patients. To encourage sufficient donations to save the other 47 000 patients, the government would have to compensate living kidney donors approximately $77 000 (±50%) per donor. The value of transplantation to an average kidney recipient (and caregiver) would be approximately $1.5 million, and the savings from the recipient not needing expensive dialysis treatments would be approximately $1.2 million.

Conclusions: This analysis reveals the huge benefit that compensating living kidney donors would provide to patients with kidney failure and their caregivers and, conversely, the huge cost that is being imposed on these patients and their families by the current legal prohibition against such compensation.

Keywords: compensation, kidney failure, kidney shortage, living donors.

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Introduction

Losing the War Against Kidney Failure

Economics Nobel Laureate Alvin Roth has played a crucial role in developing paired kidney donation, which is currently saving >1100 US patients with kidney failure per year from suffering on dialysis and dying prematurely. Nevertheless, Professor Roth often points out that this is a victory in a war that we are losing.[1] The number of patients diagnosed with kidney failure each year in the United States is not only much greater than the number who receive kidney transplants; it is rising at a faster rate.[2,3] Thus, the number of patients diagnosed with kidney failure who are fated to suffer on dialysis for an average of 4 to 5 years while their health steadily deteriorates until they die prematurely has trended upward and is now >100 000 per year.

How to Win the War

Many researchers have argued that the government can substantially increase kidney donations and transplants by compensating living kidney donors.[4–7] Indeed, there is virtually unanimous agreement in the transplant community that the government should remove all financial disincentives to kidney donation.[8] This study extends that line of reasoning to its logical conclusion by asking (1) how many patients diagnosed with kidney failure each year could avoid suffering on dialysis and premature death by receiving one or more kidney transplants and (2) what level of government compensation of donors would be needed to induce this number of donations.

Premature Deaths Avoided by Transplantation

This study builds upon the foundation of the cost-benefit analysis by Held et al[9] who considered the kidney shortage to be mainly a problem for patients on the waiting list for a deceased donor kidney, causing 5000 to 10 000 of them to die each year or become too sick to receive a transplant. The authors concluded government compensation of living kidney donors of approximately $45 000 per donor would be sufficient to provide a

transplant kidney to all patients added to the kidney waiting list each year.

However, we contend the kidney shortage harms many more patients with kidney failure than just the one-fourth who are placed on the transplant waiting list. No one knows exactly how many of the other three-fourths could avoid suffering on dialysis and premature death by receiving one or more kidney transplants, but we do know that of the approximately 124 000 patients per year currently diagnosed with kidney failure, only approximately 16 000 (13%) will receive a kidney from a deceased donor. Faced with those disheartening odds, (1) some patients are discouraged from going to the trouble and expense of being evaluated to receive a deceased donor kidney; (2) some physicians are hesitant to refer patients for evaluation to spare them the risks of some diagnostic procedures (eg, coronary angiography) and the disappointment of not being approved for the list; and (3) most transplant centers use very stringent criteria for placing patients on the list to increase the likelihood of successful transplants.

Thus, the number of patients placed on the kidney waiting list is a serious underestimate of the number who might avoid premature death if there were no kidney shortage. This point has been acknowledged by the Ethics Committee of the Organ Procurement and Transplantation Network:

> "The Ethics Committee also realizes the catalyst for all transplant candidate criteria is the shortage of available organs for transplantation..... Were there an ample supply of transplantable organs, nearly every person in need could be a transplant candidate."[10]

Consistent with this line of reasoning, Schold et al[11] found a considerable overlap in life expectancy among patients receiving dialysis who were, and were not, on the waiting list. The authors concluded that if all patients with a life expectancy of >5 years while receiving dialysis were placed on the list, the number on the list would almost double. This implies that approximately half of patients with newly diagnosed kidney failure could avoid suffering on dialysis and premature death by receiving one or more transplants, not just the one-quarter who are currently placed on the list. (This cohort of approximately 62 000 kidney failure patients with the longest life expectancies on dialysis will henceforth be referred to as the "study group".)

Purpose of Study

The purpose of this study is to estimate (1) how many patients diagnosed with kidney failure each year could avoid suffering on dialysis and premature death if they received one or more transplant kidneys, (2) how much the government would have to compensate living kidney donors to induce this level of donations, and (3) what would be the costs and benefits to kidney recipients, taxpayers, and society in general if the government ends the kidney shortage by compensating donors this amount.

Methods

To perform a complete cost-benefit analysis, the results of several subanalyses have to be included. These are developed in the 6 supplements and summarized here in the main text.

Transplant Kidneys and Level of Compensation Needed to End the Kidney Shortage

The first step in our study is to use supply and demand analysis to estimate the number of donated kidneys needed to end the kidney shortage and the level of compensation needed to induce this number of donations. This is done in Appendix Table S1-1 in Appendix Supplement 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732 where we show that, on average, $1^1/_2$ transplant kidneys are needed to enable each of the 62 000 patients in our study group to avoid suffering on dialysis and premature death so a total of approximately 93 000 transplant kidneys per year are needed. There is little uncertainty surrounding this estimate because it is basically determined by the steep demand curve, which in turn is determined by the estimated number of patients with kidney failure who could avoid premature death by receiving one or more transplants. Given that approximately 22 000 kidneys per year are currently being donated (16 000 from deceased donors and 6000 from living donors), that means an additional 71 000 kidneys per year would be required.

We also show in Appendix Figure S1-1 in Appendix Supplement 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732 that government compensation of approximately $77 000 per kidney donor would be sufficient to induce the required number of donated kidneys. However, a wide band of uncertainty surrounds that estimate because we are entering an area where there is a paucity of empirical data. Fortunately, this does not present a serious problem for our study, because the level of compensation is very small compared with the huge benefits for recipients and taxpayers. Hence, it is not a crucial input in determining our main results (as shown by a sensitivity analysis in Appendix Table S1-2 Supplement 1 in Supplemental Materials found at https://dx.doi.org/10.1016/j.jval.2022.04.1732).

Costs and Benefits for a Single Transplant Recipient at the Current Time

The detailed calculations for this section are shown in Appendix Supplement 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732.

The second step in our analysis is to use these results (together with 15 other inputs shown in Table 1 and the top 2 rows of Table 2) to estimate the costs and benefits for an average patient in our study group receiving a single kidney transplant at the current time when donor compensation is prohibited (shown in column 1 of Tables 2 and 3).

In Table 2, the top 2 rows of column 1 show the life expectancy of an average study group patient on dialysis is 12.6 years, but it is 19.7 years if the patient receives a transplant (as discussed in Appendix Supplement 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732). The third row shows the difference between the 2; that is, if a patient on dialysis receives a transplant, they could expect to live an additional 7.1 years. The bottom row weights this increase by the quality of life before and after a transplant and discounts future values back to the present to produce 5.6 discounted quality-adjusted life-years (QALYs).

If these 5.6 discounted QALYs are multiplied by a consensus estimate of the value of a QALY of $150 000 and 1.333 to incorporate the benefits to the patient's caregiver (see Appendix Supplement 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732), the result rounds to $1 120 000, as shown in the top row of column 1 of Table 3. This is the discounted present value of the lifetime gain in economic welfare for a single recipient and their caregiver.

A second benefit of transplantation is the savings from a kidney recipient not needing dialysis and other medical treatments that cost an estimated $114 000 per year (from Table 1) and would have continued for the 12.6-year expected life of the patient on dialysis. Consequently, the lifetime savings from stopping dialysis therapy is $1 190 000.

Table 1. Key parameters for a cost-benefit analysis.

No.	Parameter	Value
1	Economic value of a year in good health	$150 000
2	Real interest rate (ie, nominal interest rate minus inflation; used to discount future costs and benefits)	3%/year
3	Quality of life (assuming good health = 1.0)	0.52 (while receiving dialysis therapy)
4		0.75 (after transplant)
5	Percentage of costs of patients with kidney failure paid by taxpayers (federal and state)	79%
6	Cost for all medical care while receiving maintenance dialysis therapy per year	$114000
7	Cost of a transplant procedure (including organ acquisition charge) per event	$133 000
8	Cost of all medical care for a functioning graft (including medications) per year	$34 000
9	Cost of kidney graft failure per event	$82 000
10	Half-life of first kidney transplant (due to graft failure alone, not patient death)	32.8 years
11	Average age at which 50% of patients with newly diagnosed kidney failure with the longest life expectancies would receive first transplants	53.8 years

Note. Sources for all parameters are detailed in Appendix Supplement 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732.

Row 3 of column 1 shows the cost of the transplant itself (ie, payment at the time of the transplant to all parties except the kidney donor) is approximately $133 000 (from Table 1).

Row 4 shows compensation to kidney donors is 0 because it is currently legally prohibited (ignoring the small amounts provided by the National Living Donor Assistance Center and various state governments).

Row 5 indicates the medical costs after a transplant: $34 000 per year for the 19.7-year expected life of the kidney recipient, plus an additional $82 000 when the graft fails for half the recipients in an average of (19.7)/2 years. Thus, the discounted present value of medical costs over the lifetime of the recipient is $531 000.

The net welfare gain for society over the lifetime of a kidney recipient (row 6) is just the benefits minus the costs, $1 646 000.

The addendum item at the bottom of column 1 gives the discounted present value of the savings to taxpayers over the life of the kidney recipient. Given that taxpayers currently bear approximately 79% (from Table 1) of the cost of both dialysis and kidney transplants, taxpayer savings equal 79% of (1) the savings from not needing dialysis, minus (2) the cost of the transplant, and medical costs during and after the transplant. Thus, the savings to taxpayers is $416 000 per kidney transplant recipient.

Costs and Benefits Associated With a Single Transplant Recipient When Donors Are Compensated $77 000

The third step in our analysis is to estimate the consequences of the government offering compensation to living kidney donors of approximately $77 000 per donor. The cost and benefits associated with an average recipient are shown in column 2 of Tables 2 and 3.

Table 2. Increase in life-years of a recipient from receiving a transplant, compared with remaining on dialysis (for the 50% of patients with kidney failure with the longest life expectancies).

Years		(1)	(2)
		Current situation No donor compensation (average recipient receives 1 transplant)	Donors compensated $77 000 (average recipient receives 1½ transplants)
Expected remaining lifetime (half-life in years)	If patient remains on dialysis If recipient receives 1 (col. 1) or 1½ (col. 2) transplants	12.6 19.7	12.6 25.0
Increase in life-years from receiving a transplant (vs remaining on dialysis)	Increase in life-years (unadjusted) Increase in discounted quality-adjusted life-years	7.1 5.6	12.4 7.5

Note. This table shows the increase in the expected life of a patient in our study group if they receive a kidney transplant (row 2) instead of remaining on dialysis (row 1). Row 3 indicates the difference, that is, the increase in life-years from receiving a transplant. Row 4 weights this increase by the quality of life before and after a transplant and discounts future values back to the present.

Table 3. Discounted present value of benefits and costs for a single transplant recipient (per year).

Benefits and costs	(1)	(2)
	No government compensation of donors (present situation)	Government compensates donors $77 000 (average recipient receives 1 transplant)
	($/recipient)	($/recipient)
Benefits:		
Welfare gain for recipient and caregiver	1 120 000	1 505 000
Savings from not needing dialysis	1 190 000	1 190 000
Costs:		
Cost of transplant operation	133 000	182 000
Compensation of kidney donors	0	105 000
Medical costs after transplant	531 000	616 000
Net welfare gain for society (benefits minus costs)	1 646 000	1 793 000
Addendum: taxpayer savings	416 000	206 000

Since this step is very similar to the previous one, the details have been relegated to Appendix Supplement 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732.

Results

The Costs and Benefits for All Kidney Recipients

The final step in our cost-benefit analysis is to extend it to all kidney recipients in a given situation by multiplying the outcomes for a single recipient shown in Table 3 by the number of recipients in that situation. The results are shown in Table 4 (the bottom 7 rows of which have the same format as Table 3).

Column 1 of Table 4 shows the current situation in which there is virtually no government compensation of kidney donors, and consequently, there are only 22 000 kidney transplants (from both deceased and living donors) each year. This would be sufficient to provide approximately 15 000 recipients with $1^1/_2$ transplants each (the number of transplants we calculated was necessary for a member of our study group to avoid a premature death). Hence, column 1 in Table 4 is found by multiplying 15 000 recipients by the outcomes for a single recipient (and caregiver) shown in column 1 of Table 3.

Column 2 of Table 4 shows the situation after the government has compensated kidney donors $77 000 per donor. The resulting 93 000 transplants would be sufficient to provide 62 000 recipients with $1^1/_2$ transplants each. Hence, column 2 in Table 4 is 62 000 recipients times the outcomes for a single recipient (and caregiver) shown in column 2 of Table 3. Note that the welfare gain for kidney recipients (and caregivers) from transplantation would increase >5 times to $93 billion, and the total savings from stopping dialysis would increase 4 times to $74 billion, whereas the cost of compensating donors would increase to only $7 billion.

The Key Result: Approximately 47 000 Patients Would Avoid Premature Death Each Year

The net benefit from ending the kidney shortage is shown in column 3 of Table 4 (column 2 minus column 1). The most important result is in the second row: 47 000 additional patients with kidney failure each year would avoid premature death and live significantly longer and healthier lives (62 000 transplant recipients after the shortage has ended minus 15 000 currently). In addition, the net welfare gain for society would increase by $86 billion per year, and taxpayer savings would increase by $7 billion per year.

Discussion

The Ethics of Compensating Living Kidney Donors

Some people find the idea of compensating kidney donors to be repugnant or even unethical. Fisher et al[12] summarized these concerns:

> ...financial compensation beyond recovering expenses would: (1) cause undue pressure to donate, (2) exploit at-risk individuals (such as the poor), (3) commodify the human body, (4) exacerbate disparities in access to transplants between different socioeconomic strata, (5) negatively impact public opinion, and (6) potentially lead to decreased organ donation rates.

Although a full response to these ethical concerns is beyond the scope of this study, a crucial question must be asked of all of them: are they important enough to justify the continued suffering and premature deaths of approximately 47 000 patients with kidney failure each year? As Oxford ethicist Janet Radcliffe Richards has argued[13]:

> ... the burden of proof lies on anyone who wants to block or impede some particular means of getting organs. They need to show that even though people will suffer and die as a result of that obstruction, it is nevertheless justified.

Families of Deceased Donors Should Also Be Compensated

The focus of this study has been on increasing the number of living, rather than deceased, kidney donors. This is because the

Table 4. Discounted present value of benefits and costs for all kidney transplant recipients in a given year.

	(1)	(2)	(3)
			= (2)−(1)
	No government compensation of donors (present situation)	Government compensates donors $77 000	Change due to compensation of donors
	(per year)	(per year)	(per year)
Transplants	22 000	93 000	71 000
Transplant recipients = premature deaths avoided = transplants/1.5	15 000	62 000	47 000
Benefits:	($billions/year)	($billions/year)	($billions/year)
Welfare gain for recipient and caregiver	17	93	76
Savings from not needing dialysis	18	74	56
Costs:			
Cost of transplant	2	11	9
Compensation of donors	0	7	7
Medical costs after transplant	8	38	30
Net welfare gain for society (benefits minus costs)	25	111	86
Addendum: taxpayer savings	6	13	7

supply of kidneys from deceased donors is quite limited. Less than 2% of people die in the specific manner that is necessary to recover their organs. The United Network for Organ Sharing claims they are currently recovering the kidneys in 75% of these cases for a total of approximately 16 000 kidneys per year, so even if we could recover 100% of potential deceased donor kidneys, that would provide only approximately 5000 additional kidneys, far short of the 71 000 needed to end the kidney shortage.

Nonetheless, we should compensate the families of deceased donors because not only would it be helpful in recovering the last 25% of deceased donor kidneys, but it is also essential for recovering other major organs, such as hearts and lungs, that can only be obtained from deceased donors. Presumably, the level of compensation needed to recover deceased donor organs would be much lower than the $77 000 (±50%) needed to obtain the required number of living donor kidneys.

This Cost-Benefit Framework Can Also Be Used to Analyze Other Ways of Ending the Kidney Shortage

Although our cost-benefit framework was developed specifically to analyze ending the kidney shortage by the government compensating living kidney donors, parts of it can be used to analyze other solutions to the kidney shortage. For example, significant progress is being made in producing synthetic organs through xenotransplantation, stem cell generation, and 3-dimensional printing (although the practical application of these technologies may still be years, if not decades, away). From the top 2 rows of the right column of Table 3, we can see the benefit from a single recipient in our study group receiving $1^1/_2$ kidney transplants (no matter what the source) is approximately $2.7 million. As long as the cost of producing and maintaining $1^1/_2$ synthetic kidneys is less than this, society will enjoy a net welfare gain.

Limitations of the Study

The main limitation of this study is the inevitable uncertainty surrounding the 17 inputs to our cost-benefit analysis. Consequently, all of our specific numerical results should be considered as rough approximations. In particular, there is considerable uncertainty about the right-hand segment of the supply curve of transplant kidneys (Appendix Fig. S1-1 in Supplement 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732), which leads to similar uncertainty about the level of government compensation needed to end the kidney shortage. Fortunately, this does not present a serious problem for our analysis, given that the level of compensation is very small relative to the huge benefits to kidney recipients and the savings from not needing dialysis. Hence, it is not a crucial input in determining our main results (as shown by the sensitivity analysis in Appendix Table S1-2 Supplement 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732, in which we vary the level of donor compensation over a wide range).

There is also considerable uncertainty about the percent of patients with newly diagnosed kidney failure who could avoid premature death by receiving one or more kidney transplants. Based on the limited empirical data available, we estimate 50%. Nevertheless, we show in Appendix Supplement 6 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732 how our major results would be affected if this percent were significantly higher or lower.

Conclusions

The most important conclusion of this study is that the US government could end the kidney shortage and save approximately 47 000 patients with kidney failure each year from suffering on dialysis and dying prematurely by compensating living kidney donors approximately $77 000 per donor (with a wide range of uncertainty surrounding that estimate). In economic terms, the value to society of saving all of those lives would be approximately $86 billion per year. At an individual level, the value to each kidney recipient (and their caregiver) would be approximately $1.5 million, and the savings from the recipient not needing expensive dialysis therapy would be approximately $1.2 million. Remarkably, all of these gains would be achieved at no net cost to the taxpayer; indeed, taxpayers would likely save approximately $7 billion per year.

To end the kidney shortage, it would be necessary for the government to elicit approximately 71 000 additional kidney

donations per year from living donors. Although that number may seem high, it is altogether feasible (as shown in Appendix Supplement 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.04.1732). Indeed, it is an inevitable consequence of arithmetic: a patient with kidney failure needs approximately $1^1/_2$ transplant kidneys to avoid premature death. The stark choice facing society is either incentivizing approximately 71 000 more donors to voluntarily donate a kidney each year or letting approximately 47 000 patients with kidney failure a year unnecessarily suffer and die.

This cost-benefit analysis reveals the huge benefit—in terms of longer and healthier lives—that government compensation of kidney donors would provide to patients with kidney failure and their caregivers and, conversely, the huge cost that is being imposed on these patients by the current legal prohibition against such compensation (approximately 110 deaths per day). It is stunning to realize that, had this policy of preventing a kidney shortage been in effect for the past 33 years, it would have prevented the premature deaths of more than a million patients with kidney failure.[14]

Supplemental Materials

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jval.2022.04.1732.

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